ANS/NEI Advanced Reactor Standards and Codes Virtual Workshop Presentations (via link)
June 23, 2020
10:00am – 5:00pm EASTERN

Panel Title	**Presenters**
Welcome, logistics, introductions, and workshop objectives	Marc Nichol (NEI) / John Starkey (ANS)
Panel Title	**Presenters**
ANS SPECIAL REPORT, Setting the Right Bar: How Consensus Standards Help Advanced Reactor Development Advanced Reactor Codes and Standards Needs Assessment (NEI 19-03)	Presentation 1: Steven Arndt (ANS) Presentation 2: Mike Tschiltz (NEI)
Panel Title	**Presenter**
Department of Energy Perspective on Advanced Reactor Codes and Standards	Presentation 3: Dirk Cairns-Gallimore (DOE)
Panel Title	**Presenters**
Matching of Advanced Reactor developer needs and SDO capabilities. Identifying common priorities for future activities.	Presentation 4: Lauren Latham (Southern, Molten Salt Reactor TWG Chair) Presentation 5: Michael Cohen (Terrapower) Presentation 6: Jordan Hagaman (Kairos) Presentation 7: Alex Harkness (Westinghouse, eVinci) Presentation 8: Jacob DeWitte (Oklo, Fast Reactor TWG Chair)
Panel Title	**Presenters**
Other Codes and Standards Organizations Perspectives	Presentation 9: Robert Keating (ASME Sec III) Presentation 10: Rick Swayne/Thomas Roberts (ASME Sec XI) Presentation 11: Rick Grantom (ASME-ANS JCNRM)
Panel Title	**Presenters**
Other Codes and Standards Organizations Perspectives (Cont'd)	Presentation 12: Javeed Munshi (Joint ACI-ASME 359) Presentation 13: Daryl Harmon (IEEE-NPEC) Presentation 14: Martin White (Additive Manufacturing Programs, ASTM)
Panel Title	**Presenters**
Addressing the barriers to standard creation (e.g., lack of funding, and whether a process is needed for prioritization)	Presentation 15: George Flanagan (ANS) Presentation 16: Garrett Smith (DOE) Presentation 17: Chip Lagdon (Bechtel) Presentation 18: Kent Welter (NuScale) Presentation 19: Michael Arcaro (Prism) (GE-H)
Panel Title	**Presenter**
NRC Perspectives and Role in Advanced Reactor Codes and Standards	Presentation 20: Louise Lund (NRC)
Panel Title	**Presenter**
Summarize Workshop learnings and identify key takeaways	Presentation 21: Marc Nichol (NEI)

PRESENTATION 1

American Nuclear Society

SPECIAL COMMITTEE ON ADVANCED REACTOR POLICY (SCARP)

Setting the Right Bar: How Consensus Standards Help Advanced Reactor Development

Steven A. Arndt
Chairman, ANS Standards Board

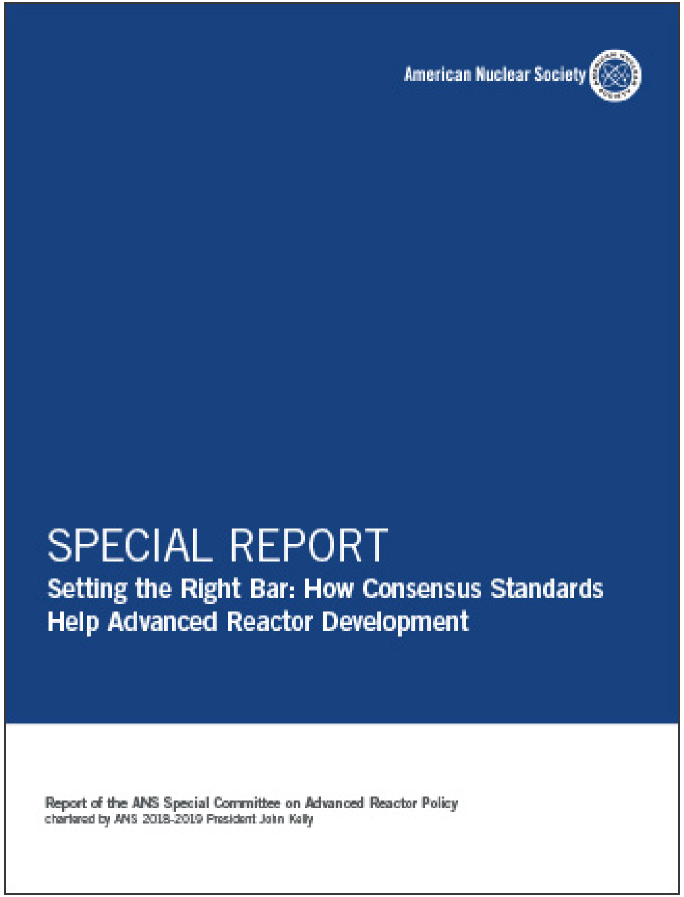
June 23, 2020

SCARP Background

- Chartered in 2018, by former ANS President John Kelly
- Surveyed existing advanced reactor-related legislation and policy proposals in order to develop integrated policy-related recommendations
- As a first product, developed an eight-page report aimed at accelerating the deployment of advanced reactors in the U.S. and abroad that best represent the consensus position of the U.S. nuclear community

SCARP Roster

- Marvin Fertel, Chair
- Art Wharton, Vice Chair
- Steven Arndt
- Robert Budnitz
- Daniel Carleton
- Michael Corradini
- George Flanagan
- Steve Nesbit
- Craig Piercy
- Piyush Sabharwall
- Mike Tschiltz
- Patrick White



In General…

The standards report was developed because it is essential all stakeholders actively support the accelerated development of advanced reactor standards

- U.S. Department of Energy
- Advance reactor developers
- Standards development organizations (SDOs)
- U.S. Nuclear Regulatory Commission

Reasoning

- Numerous countries are showing interest in the development of advanced nuclear energy designs

- There is a consensus in the U.S. that its leadership and involvement in carbon-free advanced reactor development is crucial to achieve key policy objectives related to nuclear safety, national security, and nonproliferation

- The U.S. has led the development of nuclear energy from its earliest days in the 1950s, but unless near-term actions are taken, U.S. leadership will be lost

Codes & Standards

- Have historically played a crucial role in designing, licensing, and operating light water reactors
- Reduce economic burden by avoiding unnecessary changes to designs
- Facilitate the establishment of technically appropriate safety margins
- Provide credibility for marketing advanced reactors internationally
- Help advanced reactor suppliers demonstrate and market the significantly reduced risks associated with regulatory burdens and first-of-a-kind implementation challenges

Challenges

- Developers may be concerned that the time required to develop the necessary codes and standards may impact project schedules
- In some cases, SDOs and advanced reactor developers may not have resources to commit to fully develop the desired codes and standards on the timelines needed
- Information needed to support early development of standards may not be available
- Regulators need to be more proactive in endorsing relevant codes and standards of interest

Opportunities

- The Future of Nuclear Energy in a Carbon-Constrained World — An Interdisciplinary MIT Study concluded that <u>significant project cost savings could be achieved</u> if specific codes and standards were updated and developed to reflect current technologies
- An ANS/NRC workshop in the spring of 2018 was held to develop a strategic vision for advanced reactor standards
- NEI Advanced Reactor Codes and Standards Needs Assessment (NEI 19-03)

Workshop Findings

- The workshop identified some of the key standards that must be developed or updated to support development of advanced reactors, including the following:
  - ✓ ASME/ANS RA-S-1.4, “Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants”
  - ✓ ANS-30.1, “Integrating Risk and Performance Objectives into New Reactor Nuclear Safety Designs”
  - ✓ ANS-30.2, “Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants”
  - ✓ ANS-53.1, “Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants”
  - ✓ ACI 349, “Code Requirements for Nuclear Safety Related Concrete Structures (ACI 349-13) and Commentary”

SCARP Recommendations

- In developing this report, the ANS Special Committee on Advanced Reactor Policy has worked with the ANS Standards Board and advanced reactor experts and reached out to a wide range of stakeholders from the commercial suppliers and utility community to validate our concerns and inform our understanding about the need for action
- Based on this effort SCARP developed five recommendations

SCARP Recommendations

- (1) Congress should authorize and appropriate funding for a DOE program to assist SDOs and advanced reactor developers in conducting accelerated development of and/or updates to key standards needed to implement a technology-neutral licensing framework before 2027, as mandated by the Nuclear Energy Innovation and Modernization Act (NEIMA).
- (2) The DOE, in coordination with SDOs, should solicit input from the advanced reactor developers, nongovernmental organizations, and other stakeholders to identify and prioritize key codes and standards for creation/improvement and an overall time frame for their development and regulatory acceptance.

SCARP Recommendations

- (3) The DOE should provide incentives to national laboratories to ensure proactive participation in developing the new data and methods needed to support a comprehensive overhaul of priority advanced reactor codes and standards.
- (4) The NRC should implement process improvements and/or provide the resources needed to ensure timely adoption of advanced reactor standards. The NRC should reevaluate the need for imposing margins in excess of the margins in endorsed standards and determine whether they are justified from a perspective of reasonable assurance of adequate protection of public health and safety.

SCARP Recommendations

- (5) The DOE and/or the NRC should establish a formal process with the SDOs for achieving harmonization of safety margins among new and/or updated consensus standards.

Follow-up

- Work with DOE to develop methods for funding that will assist SDOs and advanced reactor developers in conducting accelerated development of standards as recommended (particularly in recommendations 1, 2, and 3)
- Work with SDOs to use the current inputs and other resources to identify the highest priority standards
- Work with SDOs to ensure this work is priorities with all stakeholders

QUESTIONS?

steven.arndt@nrc.gov
or
jstarkey@ans.org

PRESENTATION 2

ADVANCED REACTOR CODES AND STANDARDS NEEDS ASSESSMENT

NEI 19-03 Rev 1

March 2020

Mike Tschiltz
NEI Consultant

June 23, 2020

NUCLEAR ENERGY INSTITUTE

NEI | TECHNICAL REPORT

NEI 19-03, [Rev 1]

Advanced Reactor Codes and Standards Needs Assessment

Prepared by the Nuclear Energy Institute
March 2020 Rev 1

https://www.nei.org/resources/reports-briefs/nei-19-03,-advanced-reactors-codes-and-standards

NEI Codes and Standards Needs Assessment

- Builds on prior activities by the Oak Ridge National Laboratory, American Nuclear Society and Nuclear Regulatory Commission that identified technical areas that warrant additional research and development to support standards development

- Provides a list of prioritized standards that need revision or development to support the deployment of advanced reactors

- 18 codes and standards were evaluated to be “high priority” with the potential to provide the greatest benefit for near-term development

Prioritization Process

- Prioritization was based on the benefit in terms of facilitating the licensing process and/or reducing costs for design, component fabrication, facility construction and plant operations/maintenance.

- Criteria utilized to categorize codes and standards importance include:
    1. supports design efforts;
    2. supports licensing review;
    3. reduces component fabrication time and costs;
    4. reduces facility construction time and costs; and
    5. reduces O&M costs

Scoring for Prioritization

Standards were scored to determine priority based on the following:

<u>High Priority</u>

- support design and licensing, or
- where three criteria are satisfied

<u>Medium Priority</u>

- satisfied two criteria not specifically related to both design and licensing

<u>Low Priority</u>

- satisfied one of the criteria

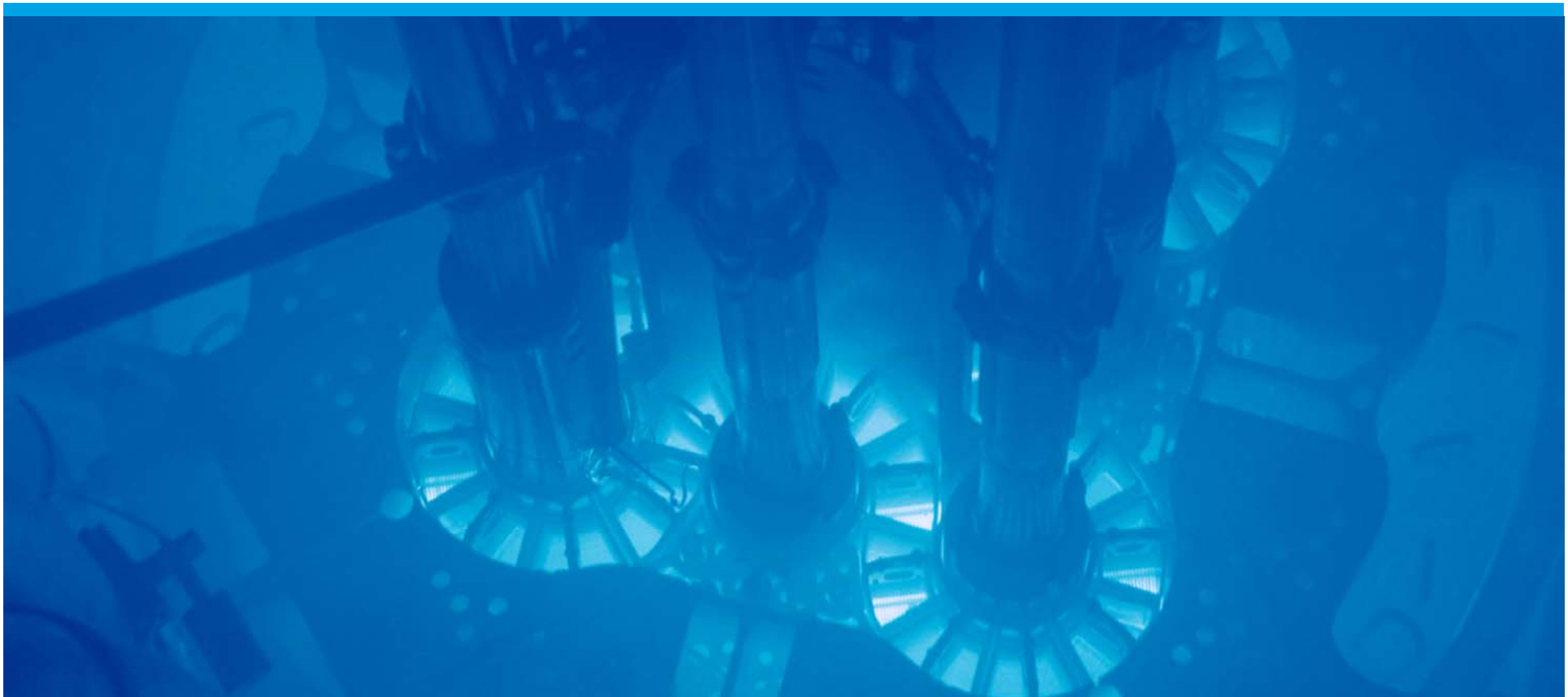
Accelerating Development

1. Coordination, prioritization and funding of activities
   - Forums for collaboration
   - Process and criteria for prioritization
   - DOE funding source / cost share with developers
2. Shortening the timeframe from “start to finish” of code/standard development and endorsement

PRESENTATION 3

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.



Reactor Fleet and Advanced Reactor Deployment

NE-5 Overview

Dirk Cairns-Gallimore
Office of Nuclear Energy

Office of Reactor Fleet and Advanced Reactor Deployment Mission

- **Vision –** Be a catalyst for the commercialization of NE-sponsored research, development and demonstration products
- **Mission –** Integrate NE's research investments to achieve a productive and balanced portfolio of competitive and crosscutting research, development, and demonstration (RD&D) and research infrastructure to enable expansion of the U.S. commercial nuclear industry
- **Objectives**
  - Full and effective integration of NE RD&D planning, execution and oversight
  - Systematic management of NE investments in research capabilities
  - Alignment of NE's RD&D programs with industry-identified technical and regulatory needs
  - Accelerate the introduction of innovative technologies into the marketplace through multiple mechanisms

Organizational Chart

NE-5

DAS for Reactor Fleet and Advanced Reactor Deployment
Alice Caponiti, Deputy Assistant Secretary
Michael Worley, ADAS
Kenny Osborne, Program Analyst
Stephen Pellegrino, Program Analyst
Theresa Bowen, Program Analyst
Julie Simmons, Secretary

NE-51
Office of Nuclear Energy Technologies

Suibel Schuppner, Acting Director
Chuck Wade, Program Analyst

National Laboratory and Industry Capabilities Team

Suibel Schuppner, Team Leader
Dirk Cairns-Gallimore, Nuclear Engineer
Dave Henderson, Nuclear Engineer
Becky Onuschak, Nuclear Engineer
Tansel Selekler, Nuclear Engineer

University Capabilities Team

Aaron Gravelle, Team Leader
Won Yoon, General Engineer
Derick Ogg, Program Analyst
Jenna Payne, Program Analyst

NE-52
Office of Nuclear Reactor Deployment

Tim Beville, Acting Director

Alison Hahn, Nuclear Engineer
Brian Robinson, General Engineer
Thomas Sowinski, Mechanical Engineer
Diana Li, Nuclear Engineer
Melissa Bates, General Engineer

Overview of Office of Reactor Fleet and Advanced Reactor Deployment

- Programs in the Office of Nuclear Reactor Deployment (NE-52)
  - Advanced Small Modular Reactor Research and Development (R&D)
  - Advanced Reactor Technologies
  - Microreactors
  - Light Water Reactor Sustainability

- Programs in the Office of Nuclear Energy Technologies (NE-51)
  - Crosscutting Technology Development
    - Advanced Sensors and Instrumentation, Advanced Methods for Manufacturing, Integrated Energy Systems, Cybersecurity
  - Nuclear Science User Facilities
  - Advanced Modeling and Simulation
  - Transformational Challenge Reactor

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U.S. Advanced Reactor Landscape

- Over 60 companies and research institutions are working on advanced nuclear projects for a wide array of capabilities to meet the energy needs of the future
  - e.g., sodium-, gas-, lead-, molten-cooled reactors (versus LWR-cooled)
  - Significant levels of private sector investment

- Motivation for advanced reactor development
  - Potential for improved safety and
  - Various options for future commercial (civilian), limited-grid and military applications
  - Potential for improved nuclear resource utilization and reduced nuclear waste
  - Flexible operation to support the national grid of the future containing many energy-source options
  - Application of advanced manufacturing and modeling techniques to bring nuclear into the 21st century

- New DOE Advanced Reactor Demonstration Program
  - $230 million initial year funding to establish a program to demonstrate multiple advanced reactor designs at various stages of technological maturity
  - Construction of two demonstration reactors within five to seven years
  - Solicitation under way; awards to be announced in fall 2020

Goal of the ARDP

- Focus DOE and non-federal resources on the construction of real demonstration reactors and supporting activities for commercial use
- Congress funded DOE to establish a program to demonstrate multiple advanced reactor designs
- Technology agnostic – all advanced technologies are eligible, including LWR-based designs
- Construct and demonstrate several advanced reactors with beneficial capabilities, such as:
  - Inherent safety features
  - Superior reliability
  - Lower waste yields
  - Proliferation resistance
  - Greater fuel utilization
  - Improved thermal efficiency
  - Ability to integrate electric & non-electric applications

Funding Opportunity Announcement Structure

Candidate organizations can submit applications under one of three pathways:

- Advanced Reactor Demonstrations (Demos)
  - Closest to commercialization
  - Deployment and operation 5-7 years following award
  - 2 potential awards at $80 million (M) each from fiscal year (FY) 2020 funds to initiate projects

- Risk Reduction for Future Demonstrations (Risk Reduction)
  - Substantial risks remain to be addressed before designs can be demonstrated
  - Commercial horizon approximately 5 years later than the Demos
  - 3-5 potential awards will split $30 M from FY 2020 funds

- Advanced Reactor Concepts-20 (ARC-20)
  - Design maturity is lowest Technology Readiness Level (TRL) scale
  - Commercialization horizon in the mid- 2030’s
  - At least 2 awards will split $20 M from FY 2020 funds

Other DOE Activities and Capabilities Supporting Industry in Advanced Reactor Development

- National Reactor Innovation Center (NRIC)
  - Addresses key gaps & barriers to enable developers to demonstrate nuclear reactor concepts supporting commercialization
  - Provides well-characterized locations to site reactors, access to key resources, and promotes collaboration with laboratory experts in nuclear science and engineering to support technology development
- Gateway for Accelerated Innovation in Nuclear (GAIN) Initiative
  - Allows industry access to DOE lab RD&D infrastructure to achieve faster and cost-effective development of innovative nuclear technologies toward commercial readiness
    - Nuclear and radiological testing facilities, e.g., thermal-hydraulic loops, control systems testing
    - Computational capabilities along with state-of-the-art modeling and simulation tools
    - Information and data through knowledge and validation center
    - Land use and site information for demonstration facilities
- US Industry Opportunities for Advanced Nuclear Technology Development FOA (Industry FOA)
  - Currently 3 application review cycles per year
  - Cost shared cooperative agreements with industry (Requires between 20% – 50% industry contribution)
  - Project funding aligned with NE programs with same goals
- Advanced Small Modular Reactor (SMR) R&D Program
  - Focuses on cost-shared, private-public R&D partnerships to address technical, operational, and regulatory challenges specific to SMRs

Advanced Reactor Potential Advantages

- Construction timelines for advanced designs expected to be shorter than the current generation of LWRs
- Advanced designs will take advantage of advanced manufacturing techniques and modular construction capability
  - Hands-on labor costs significantly reduced
  - Most work done in a controlled factory environment vs. field
  - Increased repeatability and quality, reducing component inspection times and rejection rates
- Simplicity of design reduces system and component complexity
- Reduced commodity and labor costs (steel, concrete, and rebar) due to smaller systems and lower pressures

Importance of Codes and Standards to Advance Reactors

- Standards provide the basis for efficiency, standardized products, improved trade and commerce, and safety and quality objectives
- Incorporate the evolving technical advancements and lessons-learned from real world use to ensure the standard continues to be relevant
- Set minimum requirements to protect health, safety, general welfare & affordability
- They set an understandable and reliable basis that reduces vulnerability to a wide range of hazards.
- Serves as a common language in increasing interconnected industrial complex

DOE Role in Codes and Standards

- Providing technical experts to key working meetings and as coordinators
- Accelerating the identification of gaps in the standards development process and the methods to close the gaps
- Providing support for international standards meetings
- Supporting research and development activities needed for standards development
- Supporting the codes and standards adoption process.

Summary

- DOE-NE provides sustained investments to supports codes and standards develop
- The Advanced Reactor Demonstration Program provides a unique opportunity to advance the development and application of new standards
- DOE-NE investments in Advanced Manufacturing increase stakeholder participation (Industry, DOE offices, Standards, NRC, National laboratories etc.)

Questions?

Clean. **Reliable.** **Nuclear.**

PRESENTATION 4

MOLTEN SALT REACTOR TECHNOLOGY WORKING GROUP

LAUREN LATHEM

Southern Company

Near-term		Long-term
Practical	vs	Efficient
Exploratory		Best practice
Customized		Standardized

Near-term	vs	Long-term
Practical		Efficient
Exploratory		Best practice
Customized		Standardized

PATH FORWARD

near-term, design specific demonstrations will lay the foundation for long-term codes and standards

Molten Salt Reactor TWG →

ONE

Terra Power

Fast
Breeder
Liquid Fuel
Salt Cooled
Uranium
(Could use Th)

TWO

Thorcon

Thermal
Burner
Liquid Fuel
Salt Cooled
Thorium

THREE

Terrestrial Energy

Thermal
Burner
Liquid Fuel
Salt Cooled
Uranium
(Could use Th)

FOUR

Flibe Energy

Thermal
Breeder
Liquid Fuel
Salt Cooled
Thorium

FIVE

Muons Inc.

Thermal
Burner
Liquid Fuel
Salt Cooled
Uranium

SIX

Elysium Industries

Fast
Breeder
Liquid Fuel
Salt Cooled
Uranium

SEVEN

Alpha Technology Corporation

Thermal
Breeder
Liquid Fuel
Salt Cooled
Thorium

Exelon. NEI NUCLEAR ENERGY INSTITUTE DUKE ENERGY. EPRI

MSR TWG

COLLABORATE ON TECHNOLOGY NEUTRAL TOPICS

- SALT PROPERTY MEASUREMENT
- FUEL QUALIFICATION
- MODELING AND SIMULATION TOOL DEVELOPMENT
- MATERIALS CHARACTERIZATION

EDUCATE AND BUILD RELATIONSHIPS

- MEET QUARTERLY
- PARTICIPATION NOT EXCLUSIVE TO MEMBERS

PRESENTATION 5

TerraPower

NEI/ANS Advanced Reactors Codes & Standards Workshop

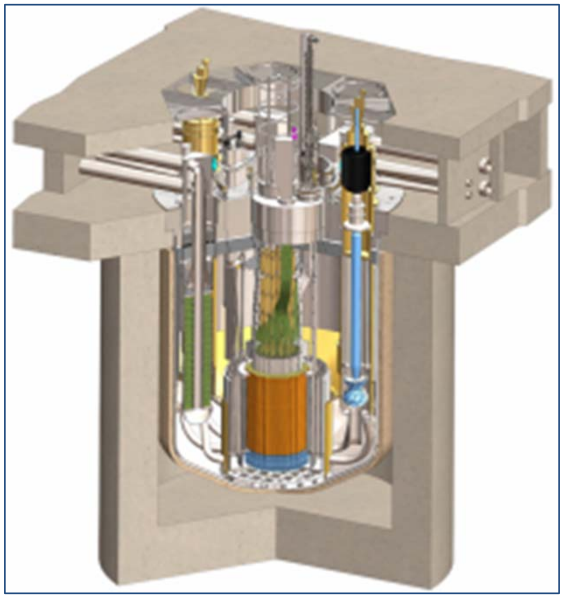
Panel Discussion: Matching of Advanced Reactor developer needs and SDO capabilities

Michael E. Cohen, P.E.

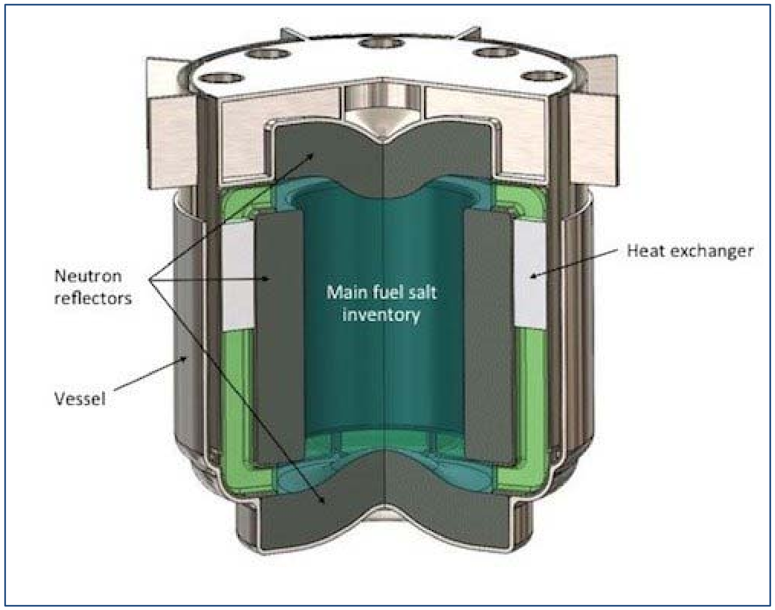
June 23, 2020

Introduction – TerraPower Reactor Concepts

Sodium Fast Reactor



Molten Salt Reactor



Consensus Codes with TerraPower Involvement

- **ASCE** DANS (4 and 43)
- **ASME** Boiler and Pressure Vessel Code
  - Section III
    - Including numerous groups under Division 5 (high temperature reactors)
    - Probabilistic Methods in Design
  - Standards Committee on Plant Systems Design (PSD)
  - Section XI (no membership)
- **ANS**-20.2-201x, "Nuclear Safety Design Criteria and Functional Performance Requirements for Liquid-Fuel Molten Salt Reactor Nuclear Power Plants"
- **EPRI** Advanced Nuclear Technology Program
- **IEEE** 497, 1012, 603, and 7.4.3.2

Important Issues

- Frequently, adapt designs because of the time to implement in codes and standards – does this make sense?
  - Use only materials that are already in “the code”
  - Use cladding along with materials that are already in “the code”
- Engagement
  - Committees have a backlog of items that we provide input to and help prioritize
  - By being active in the committee we are able to understand the issues
  - Get involved from the beginning on long lead issues (*ASME Plant Systems Design, ANS-20.2-201x*) so that we can influence them
- Will the regulator accept new rules and revisions? How long will it take?

Urgent Codes and Standards

- We get involved in the ones that we consider urgent
- C&S focused on the nuclear island because we are focusing our design on the nuclear island, and we are partnering with others to complete the design
- C&S where the issuing organizations have other codes and standards recognized by regulators
- We assume it will take time to get things through consensus codes and standards

TerraPower

Priorities

- When supporting a licensing effort. Codes, standards, methodologies, etc. that will be new to the NRC should be discussed in pre-application interactions to help identify issues as soon as possible. Early issue resolution will prevent later delays.
- Specifically
  - Areas related to safety analysis and safety related equipment
  - Supply chain may need changes for long lead items.
  - Materials not in the Boiler and Pressure Vessel Code – don't use them? Clad approved ones?
  - Integration of risk informed information

Benefits

- Design
  - Using new materials, methods, and rules may give us more design options
- Licensing
  - The changes are not necessarily being made to facilitate licensing. However, in all cases, regulator involvement is important at the codes and standards level so that they are not caught off guard by changes. Without it, it could delay licensing.
- Construction
  - For advanced reactors, components may have different safety classifications than in LWRs which may allow for reduction cost in inspection and quality assurance.
  - Streamline rules for less cost
  - Make it easier for suppliers to maintain certification
- Operations and Maintenance
  - Reduce some operational cost by taking advantage of advanced reactor features and streamlining rules for advanced reactors, e.g. risk informed in-service inspection

Timeline

- Timeframe for the designs is operating in 2028. Some C&S changes may be needed in 2-3 years to support
- We are involved with them so that we don't have to get up to speed on their use and rule-making because we know it takes time.
- Of course, we would like to be able to develop codes and standards more quickly

PRESENTATION 6

Kairos Power

NEI/ANS Advanced Reactors Codes & Standards Workshop: Matching of Advanced Reactor developer needs and SDO capabilities

23 June 2020

Jordan Hagaman
Reliability Engineering

Kairos Power’s mission is to enable the world’s transition to clean energy, with the ultimate goal of dramatically improving people’s quality of life while protecting the environment.

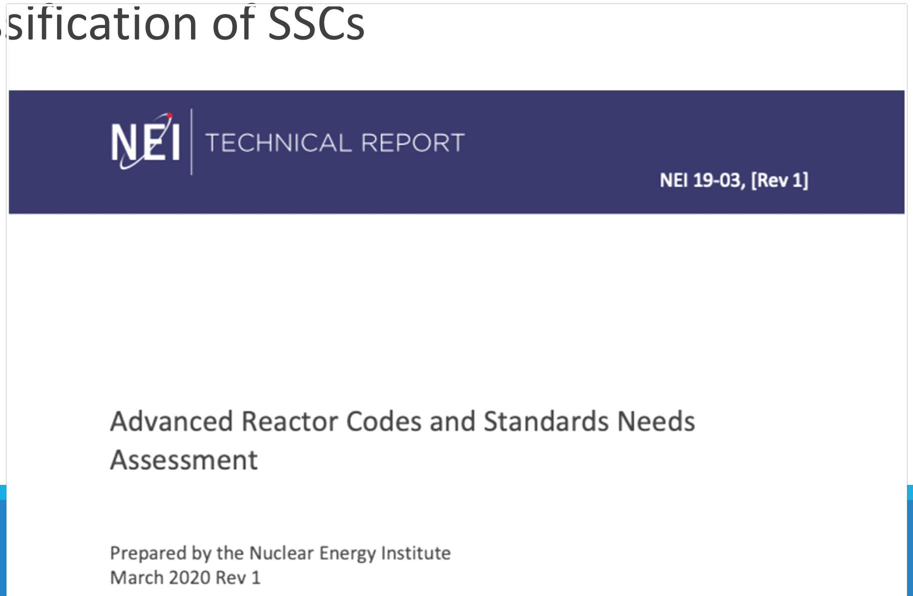
Kairos Perspective on Codes/Standards in NEI 19-03

HIGH PRIORITY

- ASME/ANS RA-S-1.4-2020 PRA for Non-LWRs
- ASME BPVC Section III, Div 5 High Temperature Reactors
- Equivalent QME-1 for Qualification of Passive Equipment
- ANSI/ISA-67.02.01-2014 Safety-related Instrument Sensing Lines
- ASME BPVC Section XI Div 2 In-service Inspection of Components

NO PRIORITY

- ANS-20.1-201x FHR Design Criteria (*discontinued*)
- ANS-30.1-201x Risk-informed Performance-based Principles and Methods
- ANS-30.2-201x Categorization and Classification of SSCs


NEI TECHNICAL REPORT

NEI 19-03, [Rev 1]

Advanced Reactor Codes and Standards Needs Assessment

Prepared by the Nuclear Energy Institute
March 2020 Rev 1

Risks and Opportunities for SDOs

RISKS

- Developing standards on topics that overlap or conflict with ongoing regulatory engagement
- Developing standards on topics before a state-of-practice is established or on process-based areas
- Tying up limited resource on efforts without clear value to vendors

OPPORTUNITIES

- Trial-Use Pilot Application for standards gives stakeholders opportunity to give specific feedback on benefits and conflicts
- Focus standards resources on technical, research-heavy topics supported by a state-of-practice
- Attract vendor participation by focusing on standards with confirmed alignment to vendor priorities

PRESENTATION 7

WAAP-11751

Westinghouse

Westinghouse eVinci™ Micro Reactor

Alex Harkness, Chief Engineer
Westinghouse Government Services, LLC

NEI/ANS Advanced Reactor Codes and Standards Workshop
June 23, 2020

Incorporating Market Requirements

- Transportability – standard shipping envelope
- Ease of operation – autonomous control
- Battery concept – entire reactor replaced; no onsite refueling
- Adaptability of design – applicable to for both heat and power
- Driven by economics – competitive with existing power sources

Reactor in a standard Intermodal Container

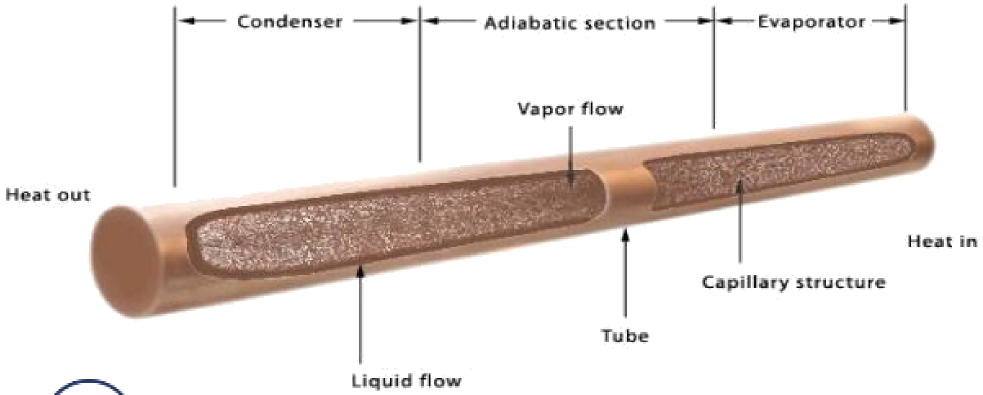
Westinghouse

eVinci Micro Reactor

Attributes

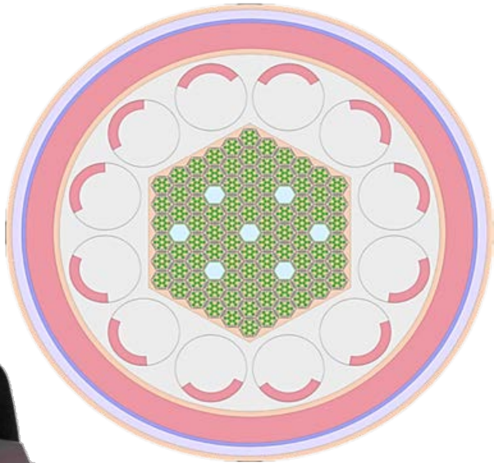
- ~2 MWe mobile energy generator, and >2 MWe for fixed installations
- Fully factory built, fueled and assembled in intermodal containers
- Passive heat pipe technology
- 40 year design life with 3+ years continuous power
- Inherent safety - no operator action or mechanical actuations
- Capable of providing high temperature process heat
- Zero emergency planning zone (EPZ)
- Small installation footprint

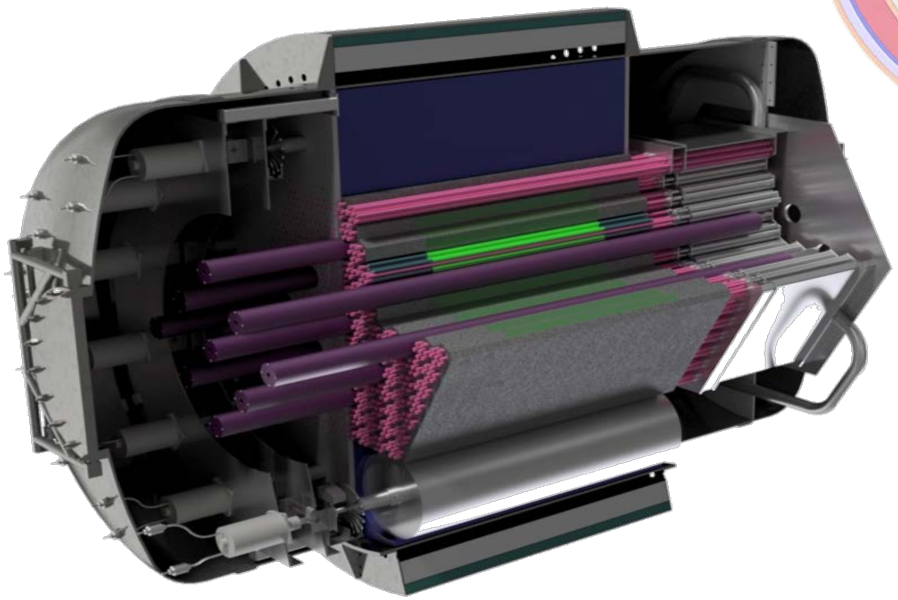
Heat Pipe Design



Westinghouse

eVinci Micro Reactor



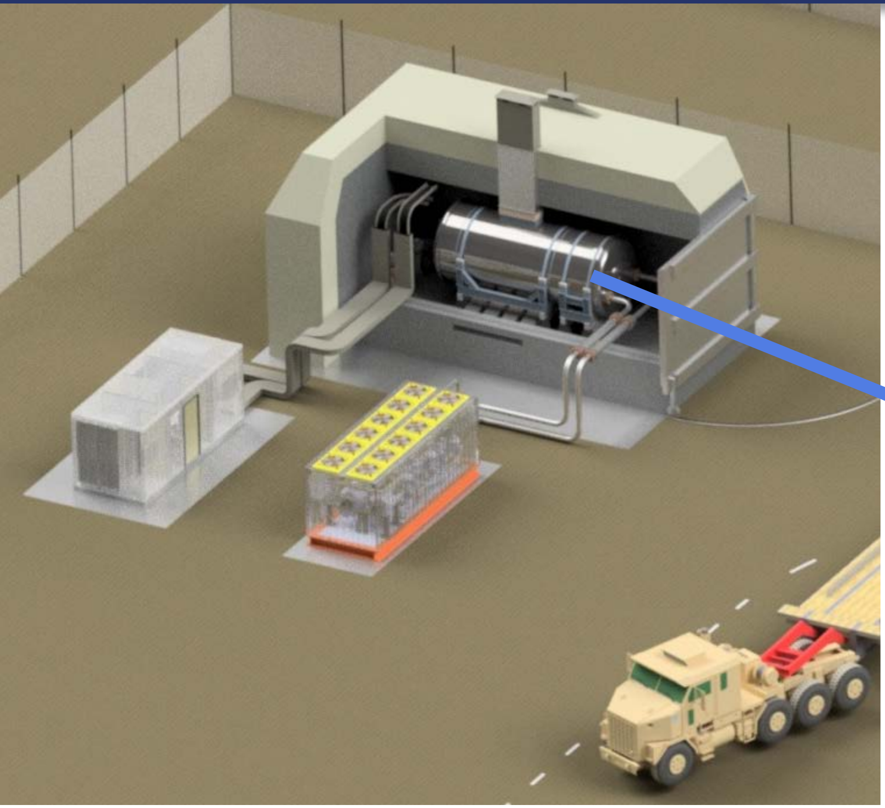


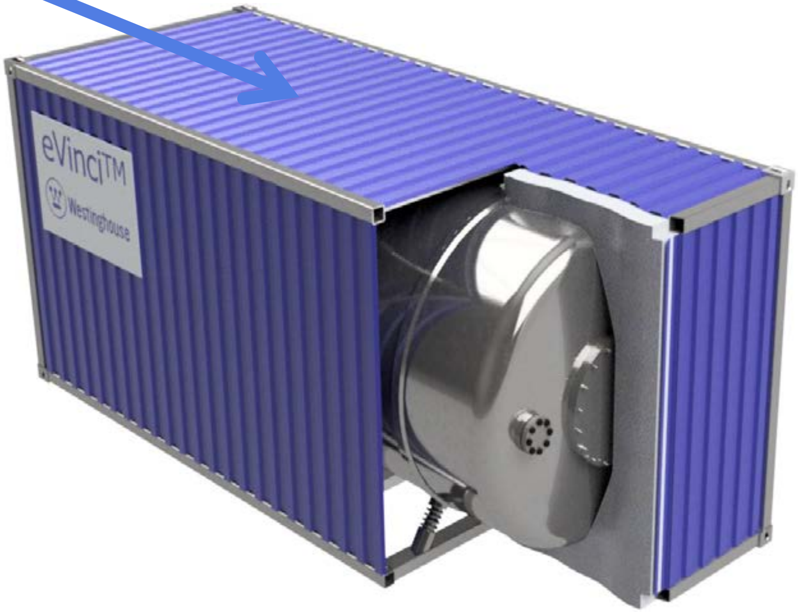
Basic Design

- Solid Monolith Core
- Sodium Heat Pipes
- High-Temperature Operation

Westinghouse

eVinci in Fixed Installations



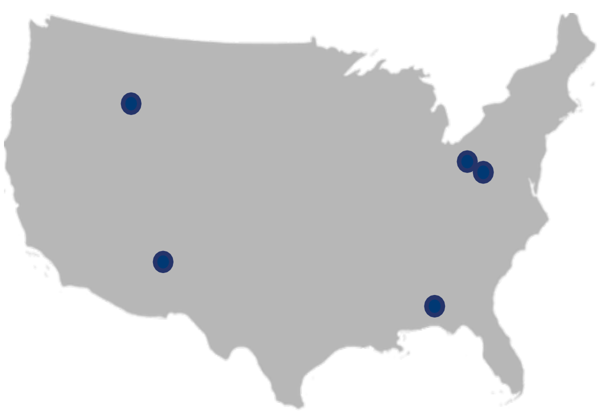


eVinci Micro Reactor Team

Technology, Capabilities and Experience

Integrated Team:

- Westinghouse
- Los Alamos National Laboratory
- Idaho National Laboratory
- Southern Company
- University of Pittsburgh



Westinghouse

Los Alamos NATIONAL LABORATORY EST. 1943

INL Idaho National Laboratory

Southern Company

UNIVERSITY OF PITTSBURGH VERITAS VIRTUS 1787

Westinghouse

Micro-reactor Development Landscape

- Shift in deployment models – factory built/site installed
- Full scale technology demonstrations – possible/expected
- Aggressive development timelines – demo by 2024
- High temperature components/materials – 800ºC +
- Shared technology with today's larger NPP – limited
- Applicable OE – limited
- Array of technologies being developed – diverse
- Licensing approach – performance/consequence based
- Priorities – continue to shift as designs mature

Challenges Presenting Opportunities

Westinghouse

Summary

- Existing codes and standards are being referenced where applicable or when the underlying principles are thought to be broadly applicable to the new technology
- Gaps are being identified and a strategy to address each is under development
- General concerns:
  - Ability of codes and standards bodies to respond to aggressive development timelines
  - Limited applicability due to design diversity draws into question the need for industry codes and standards
  - What role will codes and standards play in the licensing of advanced reactor technologies?

More Info

http://www.westinghousenuclear.com/New-Plants/eVinci-Micro-Reactor

PRESENTATION 8

Perspectives on Advanced Reactor Standards

NEI/ANS Advanced Reactors Codes & Standards Workshop:

Matching of Advanced Reactor developer needs and SDO capabilities

Jacob DeWitte

CEO and Co-Founder, Oklo Inc.

Chair of the Fast Reactor Working Group

Advanced reactor perspectives

- Variety of established and new developers pioneering new reactor design development and deployment models
- Standards are valuable resources and “tools” that can enable industrial activities
- They particularly make sense to develop and adopt when an industry is thriving, in other words after experience has been gained from first-of-a-kind or early deployment efforts
- Standard development should reflect industry activities and priorities so they are most useful

Key considerations for standards and SDOs

- Standards should reflect industry’s priorities
- Standards should be developed after a state-of-practice has been established, in other words after some work has been done so that standards are not poorly defined
- Development should be mindful of ongoing regulatory activities and avoid conflict or overlap
- Standards should focus on topics informed by research and development, and not on processes
- Prioritize resources and efforts in manners that reflect industry priorities to maximize resource efficiencies
- Use trial use pilot applications

Perspectives on codes and standards activities

Priority

- ASME BPVC Section III, Div. 5 High Temperature Reactors
- ASME BPVC Section XI Div. 2 In-service Inspection of Components
- ASME BPVC Section III Div. 1 and Div. 2
- Equivalent QME-1 for Qualification of Passive Equipment
- ASME/ANS RA-S-1.4-2020 PRA for Non-LWRs

No priority

- ANS-30.1-201x Risk-informed Performance- based Principles and Methods
- ANS-30.2-201x Categorization and Classification of SSCs

PRESENTATION 9

ASME Code Section III Standards Committee Perspectives

NEI/ANS Advanced Reactors
Codes & Standards Workshop
June 23, 2020 • Virtual Meeting

Robert Keating, PE
ASME BPV III Standards Committee, Chair
MPR Associates, Inc

Scope of ASME Section III

- Scope of ASME Code Section III is the Construction of Nuclear Components
  - General Requirements
  - Materials
  - Design
  - Fabrication
  - Examination
  - Testing
  - Overpressure Protection
  - Certification and Stamping

Scope of ASME Section III (cont)

- Division 1 (Traditional LWR)
- Division 2 (Concrete Containment)
- Division 3 (Spent Fuel Containment)
- Division 4 (Fusion Reactors – Draft)
- Division 5 (High Temperature Reactors)

ASME SETTING THE STANDARD

Scope of ASME Section III (cont)

- Types of Components
  - Vessels
  - Valves
  - Pumps
  - Piping
  - Metal and Concrete Containment Vessels
  - Supports
  - Core Supports and Internals
  - Spent Fuel Shipping and Storage Containments

Section III Strategic Activities

- Current Active Initiatives:
  - Modernization of Seismic Design Rules
  - Implementation of Fatigue Action Plan
  - Development of Inelastic Design Rules
  - Advanced Manufacturing
  - Adding Value to the Code
- Currently Division 5 (HTR) is under review by US NRC for endorsement
  - Draft Regulatory Guide by Spring 2021

ASME
SETTING THE STANDARD

Modernization of Seismic Rules

- Seismic has an outsized impact on the plant design such as HELB, Seismic II/I design, etc.
- Objective is to update and enhance existing seismic design rules; Develop new rules as needed
- Seismic may control the design of several types of advanced reactors – how to address?
- Adjust and modify the existing Code Design requirements, don't add new requirements
- Develop implementation Road Map (EOY 2020)

ASME SETTING THE STANDARD

Fatigue Action Plan

- Near term goals
  - Code Case for simplified elastic-plastic analysis to reduce conservatism
    - *Approved for publication*
  - Code Case to account for through thickness stress gradient in piping
    - *Approved for publication*
  - Revise procedure for use of results from plastic analysis
  - Procedure and minimum data requirements for new fatigue design curve
  - Adopt proposed design curves for carbon and low alloy steels in NUREG/CR 6909-1

Fatigue Action Plan (Cont'd)

- Longer term goals
  - Review justification for strain amplitude threshold for EAF
  - Evaluate alternate methods for cycle counting
  - Develop multiple best fit curves for carbon and low alloy steels based on material spec. or ultimate tensile strength
  - Develop multiple best fit curves for Ni-Cr-Fe and stainless
  - Develop method for adjustment for mean stress effect
  - Evaluate and select new design factor on cycles and stress
  - Evaluate incorporation of stress/strain amplitude threshold for growth of mechanically significant crack
  - Update CC N-792 based on NUREG/CR 6909-1

ASME SETTING THE STANDARD

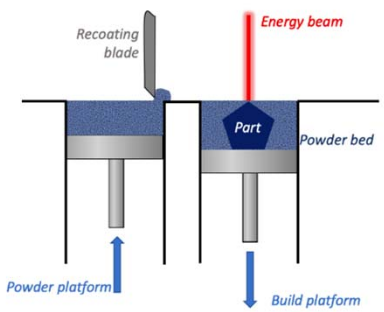
Inelastic Design Methods

- Elastic Perfectly Plastic Methods (screening tools):
  - Use elastic perfectly plastic stress analysis to bound:
    - Creep rupture under sustained load
    - Strain and creep-fatigue under cyclic load
  - No stress classification or linearization
  - Applicable over full temperature range
  - Simplifies design and analysis of complicated geometries
- Inelastic analysis methods (more accurate):
  - New Appendix HBB-Z
    - Part I: Guidelines for inelastic material models
    - Part II: Constitutive models, with explicit formulas and parameters
      - Current: Grade 91; In development: 316H, Alloy 617
      - Future: remaining Class A materials

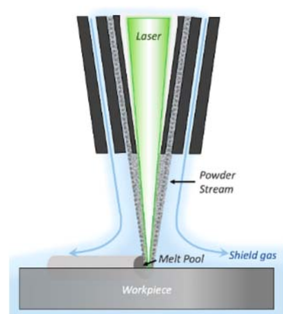
ASME SETTING THE STANDARD

Advanced Manufacturing (AM)

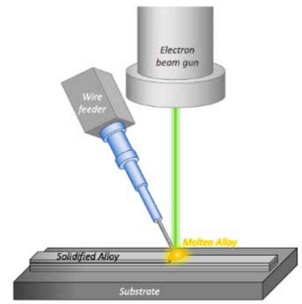
- Enable complex component geometries, increase design flexibility and enable more efficient designs
- Reduce the number of steps in fabricating components compared to traditional fabrication processes – leading to significant cost reduction



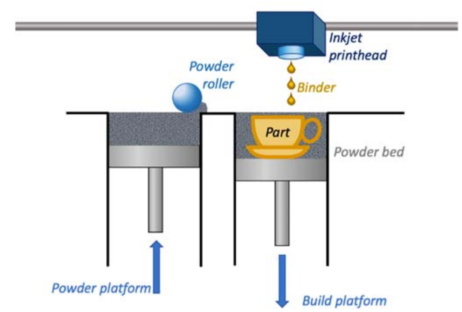
Powder-Bed Fusion (PBF) process



Directed Energy Deposition (DED) process with powder feed



Electron Beam Welding (EBW) process with wire feeder



Binder Jetting process with colored binder

- New Task Group (Division 5 AM Components) formed to determine approaches for qualifying materials processed by AM methods and specifying acceptance criteria for components

ASME
SETTING THE STANDARD

Adding Value to the Code

- Goal is to eliminate unnecessary requirements that increase cost but are of are minimal impact on safety
- Exploring Graded QA for Low Safety Significant Components
  – Design rules are well suited for nuclear design
  – QA rule largely driven by LWR risk and safety profile
  – Goal is appropriate design rules with cost consistent with risk
- Looking at certification, documentation and other areas that add cost, but have minimal value to increasing safety

ASME
SETTING THE STANDARD

Committee Priorities

- Committee Priorities are established by the Section III Executive Committee
- Executive Strategic Advisory Board
  - Executives from Nuclear Stakeholders
  - Operators, NSSS Vendors, N Certificate holders, Regulators, International Users
  - Includes advanced reactor developers
  - Meet on an on-going basis to seek guidance, advice, feedback and help set priorities

SETTING THE STANDARD

Required Resources

- Section III relies on volunteers meeting four times a year to maintain the code:
  - New rules
  - Revisions
  - Code Cases
  - Interpretations
- Volunteers to do the work
- Known the needs of stakeholders
- Research to support advancements

HTR Workshop

- Introduce Division 5 to Advanced Nuclear developers and stakeholders
- Advanced Nuclear developers to introduce their reactor concepts and their Codes and Standards needs
- Presentations from developers (current commitment)
  – Advanced Reactor Concepts, LLC • BWX Technologies, Inc. • Flibe Energy • Framatome • GE Hitachi Nuclear Energy • Kairos Power • Moltex Energy • TerraPower • Terrestrial Energy • ThorCon • Ultra Safe Nuclear Corporation • X-Energy
- Sunday, November 8, 2020, Atlanta, GA
  – Pre-registration: https://www.asme.org/conferences-events/events/asme-bpv-iii-division-5-workshop-high-temperature-reactors

Section III Division 5 Workshop

Sunday, November 8, 2020, Draft Agenda (Rev. 2)

TerraPower Copyright (2020)

Time	Item	Presenter	Duration
8:00 AM	Welcome & Introduction	TBD	30
8:30 AM	Division 5 Overview	Sam Sham	25
8:55 AM	Division 5 Gap Analysis Reports	Bob Jetter	25
9:20 AM	Regulatory Guidance	Andrew Yeshnik (US Nuclear Regulatory Commission); Xuejun Wei (Canadian Nuclear Safety Commission)	40
10:00 AM	Break		30
10:30 AM	Design and Materials - Metallic	Mark Messner; Richard Wright	40
11:10 AM	Design and Materials - Nonmetallic	Will Windes	25
11:35 AM	ASME and Advanced Reactor Developers Interaction	Mike Cohen	25
12:00 PM	Lunch (On Your Own)		60
1:00 PM	Presentations from Advanced Reactor Developers (I) Advanced Reactor Concepts, LLC • BWX Technologies, Inc. • Flibe Energy • Framatome • GE Hitachi Nuclear Energy • Kairos Power • Moltex Energy • TerraPower • Terrestrial Energy • ThorCon • Ultra Safe Nuclear Corporation • X-Energy (List will be updated with more confirmation.)		120
3:00 PM	Break		30
3:30 PM	Presentations from Advanced Reactor Developers (II)		90
5:00 PM	ASME-Advanced Reactor Developers Discussion		30
5:30 PM	Workshop Adjourns		

ASME SETTING THE STANDARD

PRESENTATION 10

INTRODUCTION TO SECTION XI, DIVISION 2 RELIABILITY AND INTEGRITY MANAGEMENT (RIM) PROGRAM

FIRST ASME RIM PUBLICATION IN JULY 2019

AN INTERNATIONAL CODE
2019 ASME Boiler & Pressure Vessel Code
2019 Edition July 1, 2019

Division 2
Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Power Plants

OUTLINE OF RIM

- Section XI Division 2 Reliability Integrity Management (RIM) overview.
  - What is RIM and why is it essential to Advanced Reactor designs?
  - What is important about RIM that Advanced Reactor designers should consider during design?

CHALLENGES FOR ADVANCED DESIGN REACTORS

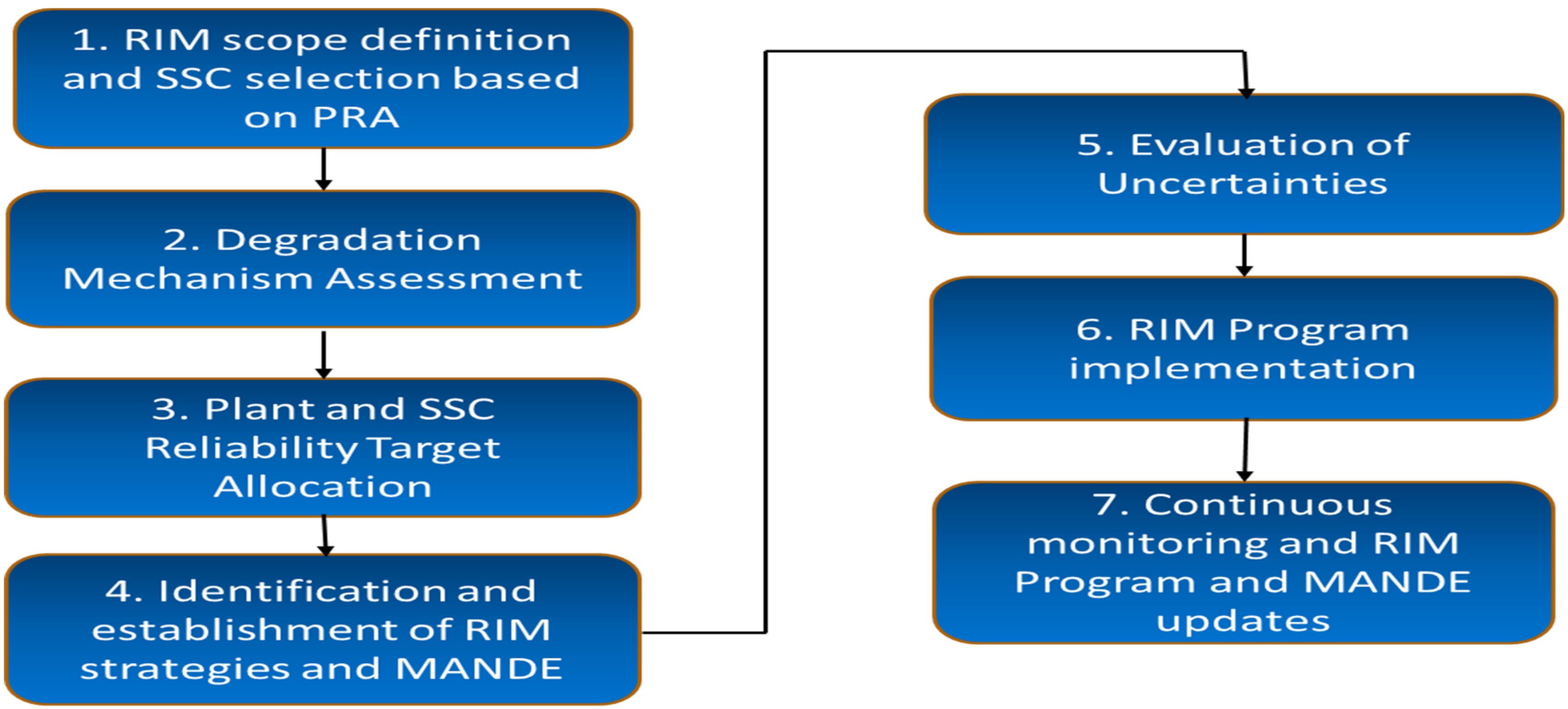
- Present ASME Section XI Division 1 is **not well suited** for many advanced design reactors currently under development.
- Division 1 was developed for, and evolved around Light Water Reactor technology (e.g., BWRs & PWRs).

RELIABILITY INTEGRITY MANAGEMENT (RIM)

ASME Section XI Sub Group – RIM developed a new ASME XI Division 2

- Reliability and Integrity Management (RIM) - A methodology to establish Inservice Inspection criteria regardless of technology.
  - RIM is "technology neutral“ – applicable to all reactor designs
  - RIM criteria may be established by deterministic or probabilistic means
  - RIM requires Monitoring and NDE **(MANDE)** to be assigned to SSC based on credible degradation mechanisms and their individual contribution to risk significance.

RELIABILITY INTEGRITY MANAGEMENT (RIM) PROCESS CONCEPTS



RIM PROCESS DESCRIPTION:

- MANDE selected must be based on:
  - ❑ SSC credible and <u>postulated material degradation assessment</u>
  - ❑ MANDE must be <u>***"Performance Demonstrated"***</u> to confirm that a required SSC's Reliability Targets is met

- <u>**Any SSC**</u> that could affect plant reliability are scoped into the RIM program.
  - ❑ All SSC are initially evaluated to determine if they need to be included within the program scope.
  - ❑ Non-Safety Related SSC <u>deemed risk significant</u> are also contained in RIM program.

This contrasts the existing ASME XI Div. I Class I, Class 2, Class 3, Class MC, Class CC, etc. ISI approach, with each class having different graduated criteria based on the class of an SSC rather risk significance.

RIM PROCESS DESCRIPTION:

- RIM is an on-going "Living Program" that applies over the entire plant life cycle:
  - Continually updated based on gained Operating Experience
  - **<u>Not focused exclusively on weld examinations</u>**
  - Periodicity for prescribed MANDE is based on SSC's:
    - Active degradation mechanisms
    - Reliability Target value and,
    - Operating conditions (e.g., longer fuel cycles than PWR or BWR)

ADVANCED REACTOR DESIGNERS CONSIDERATIONS:

- Integrating RIM considerations during conceptual and detailed design efforts including:
  - Establishing risk significant SSC via RIM and PRA,
  - Establishing credible degradation mechanisms,
  - Setting Reliability Target values for SSC,
  - Establishing and demonstrating MANDE selected for SSC in the RIM Program
- Working with ASME XI Division 2 committees to update and revise RIM, to address specific or unique reactor design considerations to best accommodate any reactor design as it evolves.

SUMMARY

- Advanced nuclear reactors have varied designs
    - Alternative-approach to current ISI activities are needed to accommodate new technologies.
    - Technology is moving to designs **<u>other than</u>** traditional LWRs
    - Some proposed reactors are for applications other than power production (e.g., medical isotope production, desalination, experimental test reactors, etc.)
    - RIM was developed to address and accommodate these new designs.

SUMMARY

- RIM process can be used:
  - ❑ For any reactor design or application.
  - ❑ It provides targeted MANDE criteria for an unique designs.
  - ❑ It serves as a living program to monitor aging effects on risk significant SSC
- Nuclear power is moving toward new designs, miniaturization, etc. but reactor safety and long term reliability remains paramount
- RIM can accommodate these changes while maintaining long term safety and reliability

QUESTIONS

??????????????????????

PRESENTATION 11

NEI-ANS Workshop on Advanced Reactor Codes and Standards

Codes and Standards Organization's Perspectives

Session 1

ASME/ANS Joint Committee on Nuclear Risk Management (JCNRM)

C.R. (Rick) Grantom (ASME JCNRM Co-Chair)

Robert Budnitz (ANS JCNRM Co-Chair)

June 23, 2020

ASME/ANS JCNRM Perspectives

What is the JCNRM?

The JCNRM is comprised of 35 committee members and over 150 other risk professionals, responsible for establishing requirements and guidance on technical risk management and analysis as applied to decision making for nuclear facilities. Its principal activities in the last ten years have been to develop and maintain power-reactor PRA standards and support risk applications.

(https://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=100186782&Action=37173)

Key JCNRM Priorities

- Support Current LWR Fleet and future SMR/NLWR fleets
- LWR PRA Standard New Edition (ASME/ANS RA-S-1.1) (existing version is endorsed by NRC in RG 1.200).
- Non-LWR PRA Standard (ASME/ANS RA-S-1.4) (expected to be NRC endorsed)
  - Intended to support Non-LWR applications
  - Support the Licensing Modernization Project (e.g., Licensing Basis Events, Safety Classification of SSCs)

ASME/ANS JCNRM Perspectives

Challenges

- Continuous improvement in our standards to meet stakeholder expectations
- Technical requirement consistency between various PRA Standards
- Regulatory and Industry acceptance of PRA quantifications supporting decision making & risk-informed applications
- Appropriateness of industry data and analysis models as applied to new designs
- Use of absolute vs. relative risk significance criteria
- Treatment of passive safety function reliability
- Supporting PRA during different stages of design and licensing

JCNRM Future Targets

Future Standard/Guidance Products underway or in discussion in the areas of:
- Physical/Cyber Security Programs
- Risk Informed Emergency Preparedness Programs

Continue Support of Current Applications such as:
- Risk Significance SSC Categorization (e.g., 50.69)
- Risk Managed Technical Specification
- Aging Management
- Use in other licensing-regulatory applications for the existing LWR fleet.
- Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors (Reg. Guide 1.233)

PRESENTATION 12

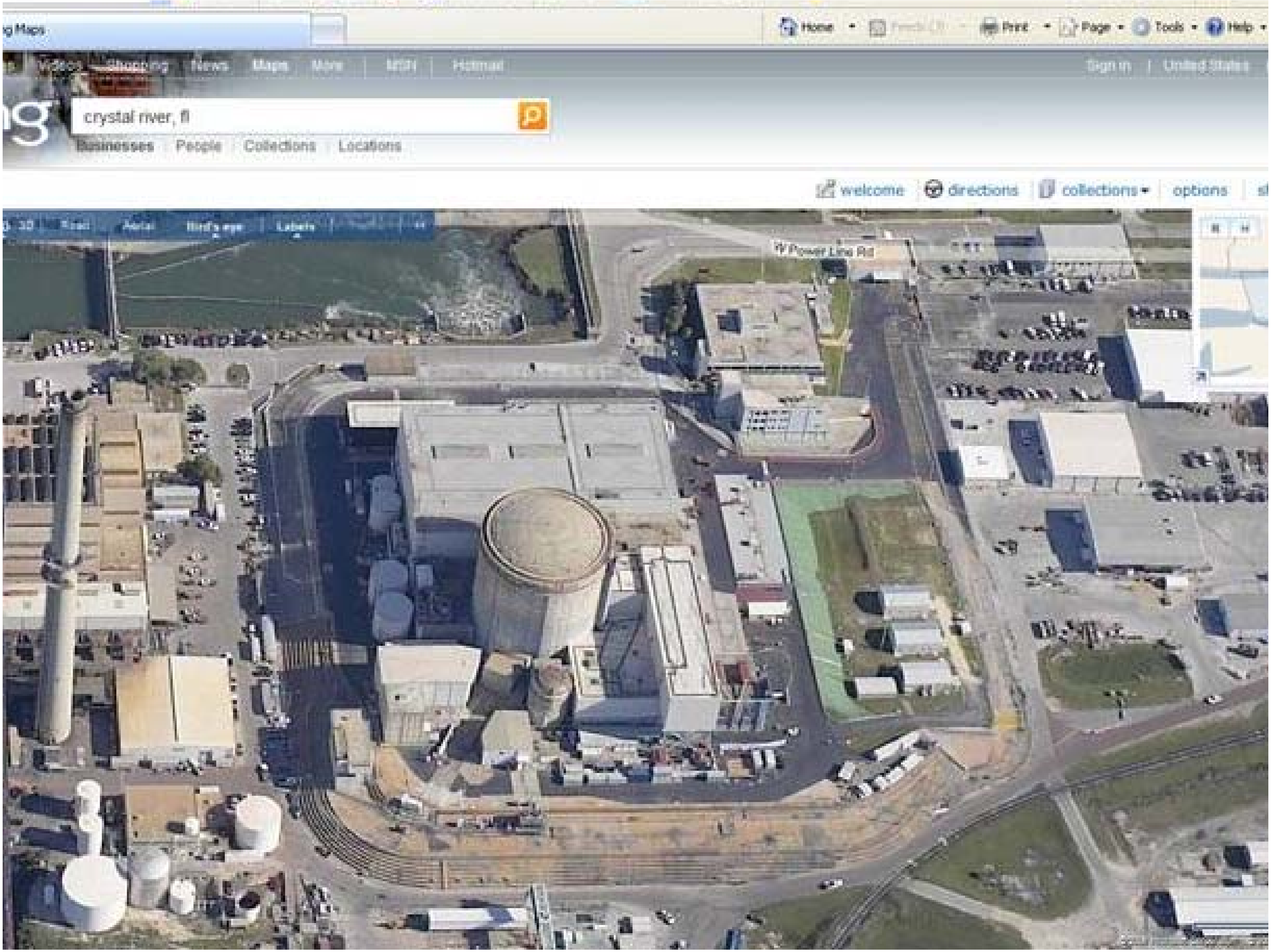
ANI- ANS Workshop On Advanced Reactors
Codes and Standards Organization Perspective

ASME Section III, Div. 2 Code

Javeed Munshi & Neb Orbovic
ASME Section III, Div. 2

ASME Section III, Div 2 for Concrete Containments

- **Background – Concrete Containments**
- **Applicability to SMRs**
- **Case Histories**
- **Code Development Needs**
- **Challenges and Opportunities**



Maps
Home
Print
Page
Tools
Help
Videos
Shopping
News
Maps
More
MSN
Hotmail
Sign in
United States
crystal river, fl
Businesses
People
Collections
Locations
welcome
directions
collections
options
Road
Aerial
Bird's eye
Labels
W Power Line Rd

GDC

- GDC 16: Containment Design
  – leak tight barrier against uncontrolled release of radioactivity and
  – design conditions not exceeded for postulated accident

- GDC 50:_Containment Design Basis
  – includes access openings, penetrations and heat removal systems withstand with margin the pressure and temperature due to LOCA

ASME Section III, Div 2 for Concrete Containments

- **Prepared by the Joint ACI/ASME Technical Committee under the sponsorship of the American Concrete Institute and the American Society of Mechanical Engineers.**

- **These two committees produced a single document dated January 17, 1972, and entitled *Proposed Standard — Code for Concrete Reactor Vessels and Containments*.**

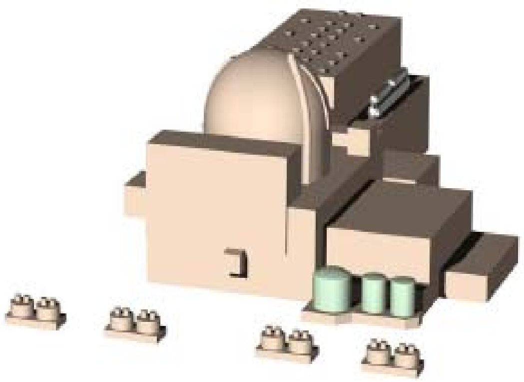
Concrete Containment CC

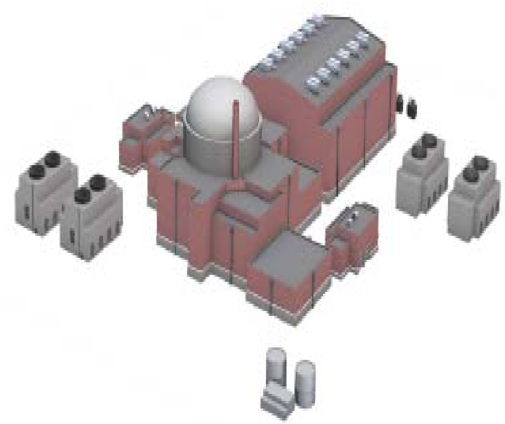
- CC 1000 Introduction or Scope
- CC 2000 Material
- CC 3000 Design
- CC 4000 Fabrication and Installation
- CC 5000 Examination
- CC 6000 Testing
- CC 7000 Overpressure Protection
- CC 8000 Nameplates, Stamping, and
- Reports

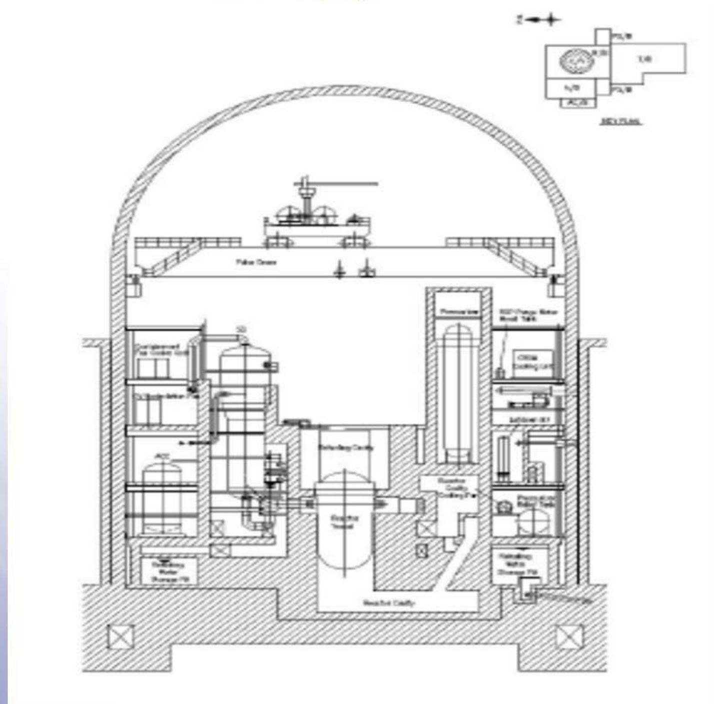
Scope

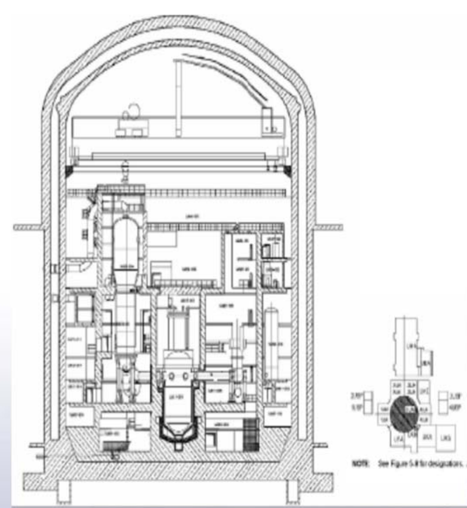
- CC-1110 SCOPE
- Establishes rules for material, design, fabrication, construction, examination, testing, marking, stamping, and preparation of reports for <u>prestressed and reinforced concrete containments</u>.
- <u>Containments having a Design Pressure greater than 5 psi (35 kPa)</u>

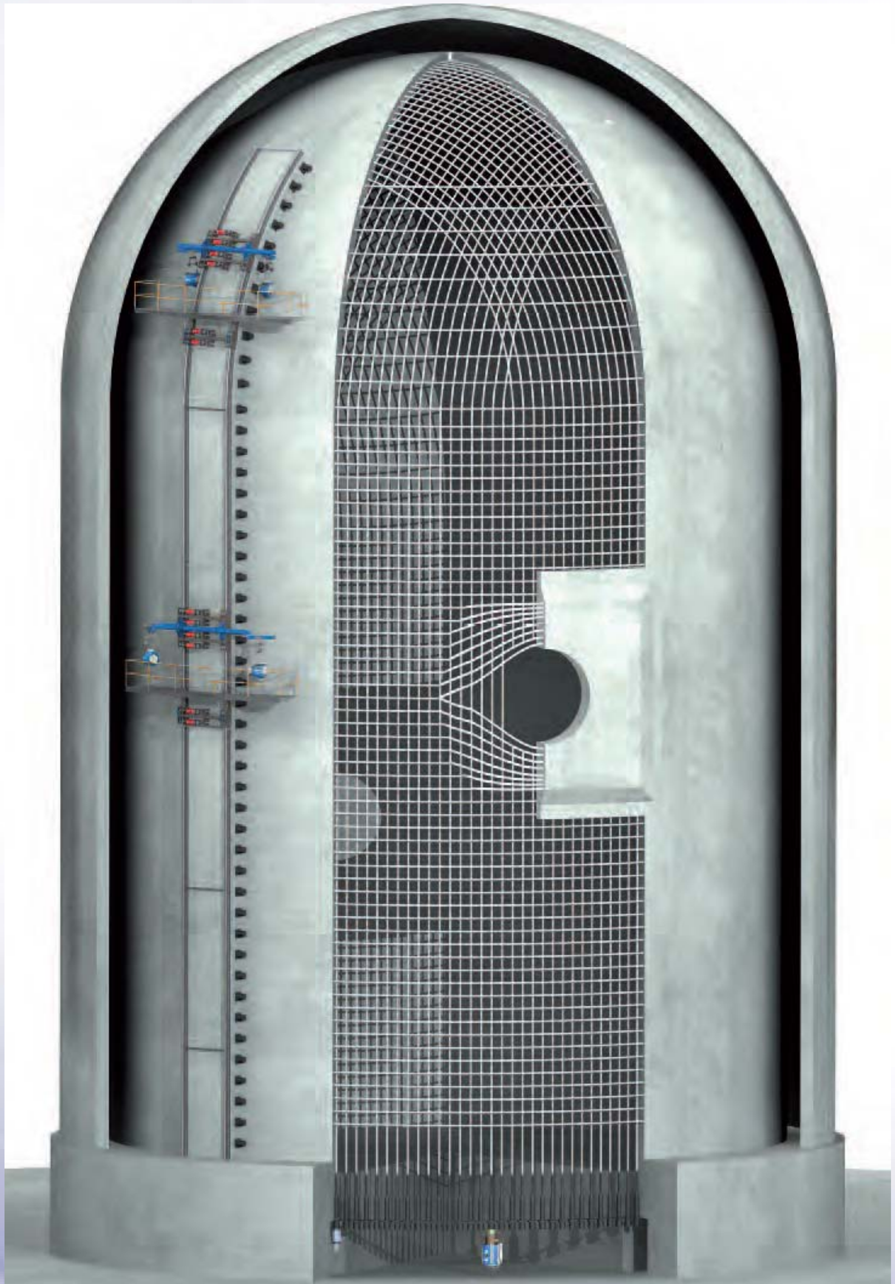
APWR & EPR



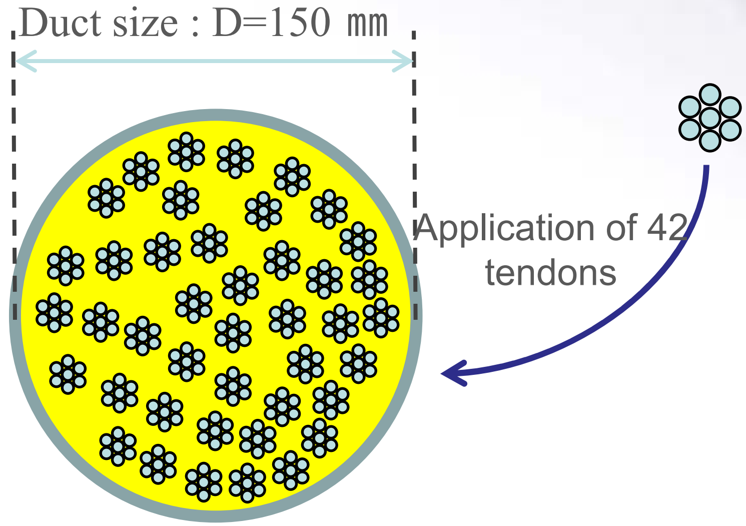








- **<u>42 bare 7-wire strands (present APR1400)</u>**
- Strand area : 140 ㎟ x 42 = 5,880 ㎟



Applicability to SMRs

- Mismatch of scale
- Regulation
- Cost and Schedule

Applicability to SMRs – Example Case

The B&W mPower Nuclear Plant

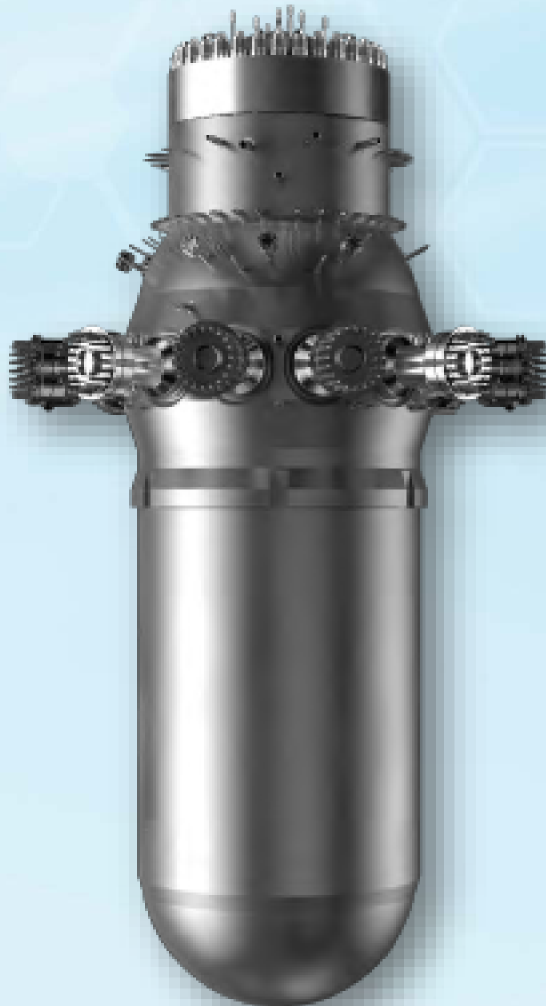
- Generic Design
  - "Twin-pack" mPower plant configuration
  - 40 acre site footprint
  - Low profile architecture
  - Water or air cooled condenser
  - Enhanced security posture
  - Underground containment
  - Underground spent fuel pool

- Underground Nuclear Island
  - Supplement to AISC N690-2011 (available in 2014)
  - Concrete design per ACI 349-06 and ACI 350.3.
  - Seismic analysis is based on ASCE 4-98, applicable sections of NUREG-0800, and with consideration to forthcoming changes in the next edition of ASCE 4
  - No exceptions anticipated
  - Turbine Island will use current commercial standards

- Modular Construction
  - Steel-concrete composites
    - No consensus standards in US
    - Supplement to AISC N690-2011 (available in 2014)
  - Civil Structural design standard for mPower
    - ACI 349, AISC N690

CAREM PROTOTYPE - BASIC FACTS

- **First NPP fully designed in Argentina**
  - Integral PWR type
  - Integrated Primary System
  - Natural circulation
  - Self-pressurized
  - 100 MW / 32 MWe
  - Enriched UO_2 fuel (3,1 and 1,8%)
  - Passive safety systems
  - Pressure suppression containment type
  - Operating cycle length of 18 months



CAREM25

Comisión Nacional de Energía Atómica

SETTING THE STANDARD

CONTAINMENT LINER

ESTIMATED PROGRESS:
78%

CAREM25

Comisión Nacional de Energía Atómica

SETTING THE STANDARD

Critical Requirements

- Rightsizing – Industry/Supplier
- Customized Regulation
- Industry Support for Design and Construction Optimization

ASME
SETTING THE STANDARD

Specific Needs for Code Development

- **Small Modular Reactors present a wide variety of technologies with different safety requirements**

- **The design requirements for the nuclear containment are different comparing to water cooled reactors**

Specific Needs for Code Development

- **Design pressure can be significantly lower, below the minimum pressure from Sec III, Div 2**

- **Some reactors do not have pressure differential (the pressure differential can be wind induced) however the containment contain flammable gas and the leak-tightness is required**

Specific Needs for Code Development

- Some SMR vendors/designers propose a new concept of nuclear containment using Steel-plate-Concrete (SC) structures
- Currently the design provisions for SC containment are not available

Specific Needs for Code Development - Example

- General Electric - Hitachi made a presentation during Sec III Div 2 Committee Meeting on June 2 regarding their intent to use SC containment for their Boling Water SMR and discussed the possibility to develop code provisions under Sec III Div 2

Challenges and Opportunities

ASME Section III, Div. 2 need to reinvent our expertise and provide technical leadership and a platform for development of viable concrete containments of the future

Use advancements in materials, design and construction techniques

Collaborate with all stakeholders and sponsor/oversea the necessary research and development

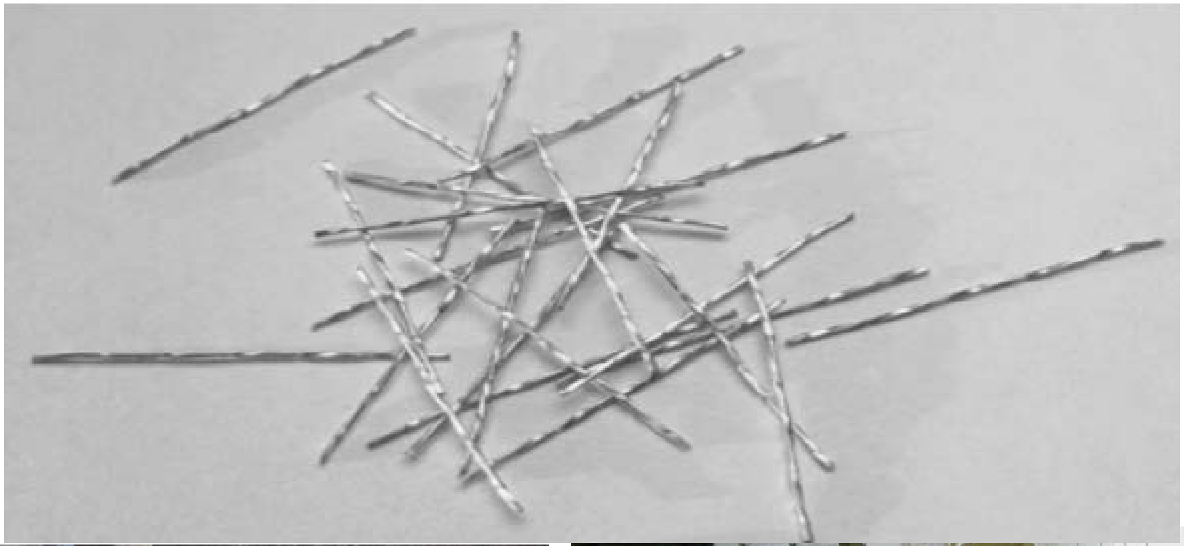
ASME
SETTING THE STANDARD

Future Direction

- Use High-Strength/High-performance materials to handle both accident pressure and SSE events
- Eliminate/Minimize conventional reinforcing
- Eliminate liner plate
- Use flowable concrete SCC with fiber reinforcement to accelerate placement time, eliminate labor for consolidation
- Use automated construction process such as slip-forming or 3D printer

Future Direction

Fiber Reinforcement and Self Consolidating Concrete (SCC)



ASME Section III, Div. 2

The Committee has embarked on a path to provide technical leadership and a platform through use of advancements in materials, design and construction techniques

We are committed to collaborate with all stakeholders and provide the necessary Code development support for a safe and viable nuclear industry of the future

ASME
SETTING THE STANDARD

Codes and Standards Organizations Perspectives
IEEE NPEC

Daryl Harmon
NPEC Chair

IEEE Nuclear Power Engineering Committee

- NPEC is responsible for developing and maintaining nuclear power plant and facility standards in the electrical and electronic area within IEEE-PES
- NPEC currently maintains 53 nuclear-related standards
- Subcommittees own 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
- Significant current initiative to develop joint logo standards with IEC

NPEC and Advanced Reactor Standards

- NPEC standards have been made reactor technology neutral to the extent possible
- Some NPEC Standards have previously been identified as being needed to support advanced reactor development:
  - IEEE Std 60780-323 (Class 1E qualification)
  - IEEE Std 7-4.3.2 (Programmable Digital Devices in Safety Systems)
  - IEEE Std 1786 (Human Factors Guide for Computerized Operating Procedures Systems)
- Feedback needed on which current NPEC standards are acceptable for advanced reactor use and needs for updating
- Currently no NPEC standards have been specifically developed for advanced reactors

NPEC and Advanced Reactor Standards

- Key issues impeding progress
  - Sufficient experience with advanced reactors is lacking to achieve a consensus for standard practice
  - Identification of advanced reactor standards needs in instrumentation and controls or human factors
    - Scalable approach to human factors to provide effective yet flexible HFE design
  - Many committee members are practitioners in the current power industry, not researchers; their employers may not see advanced reactor standards of immediate relevance and continue funding
  - Additional representatives from advanced reactor design organizations and regulators to support new standard development
  - Integrating NPEC efforts with other the efforts of other SDOs
  - Time required to publish a new standard (approximately 4 years)

Conclusion

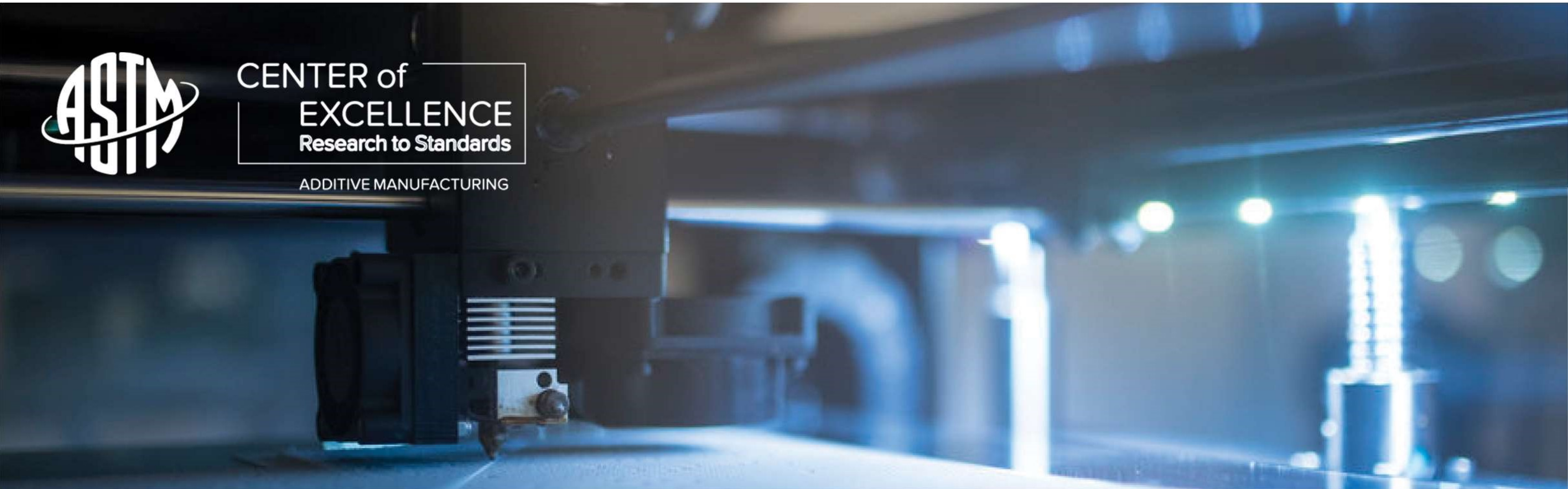
NPEC is willing and ready to develop or modify codes and standards to support advanced reactor development

- Next NPEC meetings will be held virtually

July 14-16, 2020

- NPEC Website: site.ieee.org/pes-npec

PRESENTATION 14



Advanced Reactor Developer Needs & SDO Capabilities

Dr. Mohsen Seifi, Director, Global Additive Manufacturing Programs

Dr. Martin White, Head of Additive Manufacturing Programs - Europe

NEI/ANS Advanced Reactors Codes & Standards Workshop

June 23rd, 2020
Virtual Workshop

Introduction

- **ASTM has significant history with Nuclear Industry**
  - ASTM Committee E10 on Nuclear Technology formed in 1951 – approximately 135 members
    - 74 Standards
  - ASTM Committee C26 on Nuclear Fuel Cycle formed in 1969 – approximately 145 members
    - 175 Standards
- **Introducing the ASTM Additive Manufacturing Center of Excellence**
  - Founded in 2018 – Growing team with Additive Expertise (Research & Industrial Experience)
    - Supported by F42 Additive Manufacturing Committee
  - UK Nuclear (AGR Fuel Systems, Structures & Materials) experience recently added
- **Objectives**
  - ASTM and its AM CoE is here to listen!
    - Understand challenges presented at the workshop
  - Identify where AM CoE are already providing solutions that can **immediately add value & present solutions**
  - Consider next steps:
    - **How can the ASTM support beyond this workshop?**

ASTM Nuclear Pedigree

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• E10 – Nuclear Technology & Applications:

"To promote the advancement of nuclear science and technology and the safe application of energy, including end-of-fuel-cycle activities such as decontamination and decommissioning"

- Standardizing measurement techniques and specifications for:
  - Radiation effects
  - Dosimetry, including materials response
  - Instrument response
  - Determination of radiation exposure
  - Fuel burnup.
- Standardizing the nomenclature and definitions used
- Maintaining a broad expertise in the application of nuclear science and technology, especially the measurement of radiation effects from environments of nuclear reactors, charged particle accelerators, indigenous space, spacecraft, and radioisotopes.
- Sponsoring scientific and technical symposia, workshops, and publications in the Committee's fields of specialization.

• C26 – Nuclear Fuel Cycle:

"To develop consensus standards for, and promote commercialization of, nuclear fuel cycle, materials, products and processes"

- Provide internationally accepted standards which facilitate the commerce; worker safety; public and environmental health; and regulatory compliance within the Nuclear Fuel Cycle.
- All aspects of the nuclear fuel cycle are included with emphasis on
  - Nuclear fuel
  - Reactor materials processing
  - Analysis
  - Disposal/disposition technologies and applications.
  - Nuclear fuel cycle activities of both the commercial nuclear industry and the defense community fall within the scope of this committee.
- The work of the Committee(s) will be coordinated with other ASTM International committees and national and international organizations having mutual interest.

Example Nuclear AM Projects

- UKAEA Nuclear Fusion
  - Utilization of AM at the UKAEA's Joining & Advanced Manufacturing facility
  - AM to enable new designs
  - AM Lattice structures proposed for high heat flux areas
  - Challenges include manufacture, testing, qualification -> Standardization can accelerate
- Small Modular Nuclear Reactors
  - Ongoing studies
    - UK Nuclear Advanced Manufacturing Research Centre (NAMRC)
- Small Punch Testing
  - Developed to evaluate high temperature welding integrity
  - Now used for characterizing localized AM structures and Quality Indicators
- Probabilistic Methods
  - Use establish methods for lifing of AM structures

- https://www.theengineer.co.uk/ornl-3d-printed-nuclear-reactor-core/

ASTM AM Footprint

- **Breadth**
  - More than 20 AM relevant Committees
  - 1000+ standards applicable to AM
  - 2000+ technical experts
- **History (F42)**
  - Oldest
  - Largest
  - Most globally relevant
- **Collaboration**
  - PSDO – ISO TC261 (CEN TC438)
  - MOU & Membership – America Makes
  - MOU – SME
  - Liaison Agreement – 3MF
  - Strategic Relationships – NASA, NIST, FAA, FDA, DOD, EASA, MMPDS, CMH-17, CECIMO, ….

5

ASTM F42 Fact Sheet

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Quick facts

- **Formed:** 2009
- **Current Membership:** 800+ members (154 outside US)
- **Standards:** 25+ approved, 45+ in development (Jointly with ISO)
- **Meet twice a year, next meeting:** Virtual, Sep 2020
- **Global Representation, including**

Argentina	Germany	Norway	Switzerland
Australia	India	Puerto Rico	Taiwan
Austria	Italy	Russian Federation	United Kingdom
Belgium	Japan	Singapore	United States
Canada	Korea	South Africa	
China	Mexico	South Korea	
Czech Republic	Netherlands	Spain	
France	Nigeria	Sweden	

Subcommittees and Focus

New Sub-Committee on Applications

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F42.07 Applications

Nuclear
F07
Applications

- **F42.07.01** Aviation (Charles Park, Boeing)
- **F42.07.02** Spaceflight (Rick Russell, NASA)
- **F42.07.03** Medical/ Biological (Rod McMillan, J&J and Matthew DiPrima, FDA)
- **F42.07.04** Transportation & Heavy Machinery (Sergio Sanchez, Jabil)
- **F42.07.05** Maritime (TBD)
- **F42.07.06** Electronics (Alireza Sarraf, Lam Research)
- **F42.07.07** Construction (Sam Ruben, Mighty Building)
- **F42.07.08** Oil/Gas (TBD)
- **F42.07.09** Consumer (TBD)

Scope

- The development of **standards for additive manufacturing** in a variety of industry-specific applications, settings, & conditions.
- The work of this subcommittee will be coordinated with other F42 subcommittees, ASTM technical committees, and national/international organizations having mutual or related interests.

Problem Statement

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- **AM standards development is a lengthy process**
  - Voluntary process;
  - Highly technical topics;
  - Lack of publicly available data;
  - Etc.

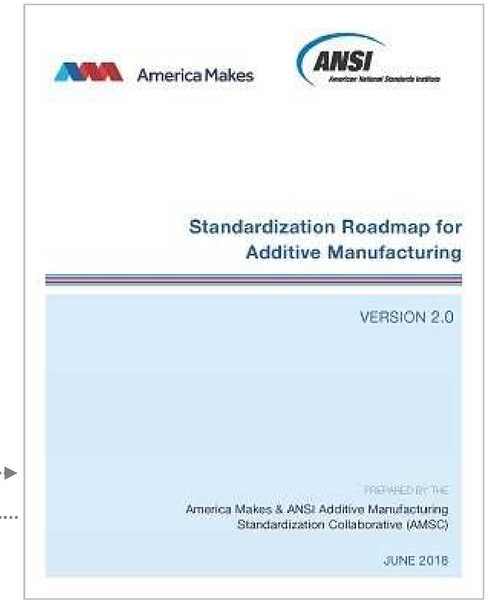
- **Current approach** could result in:

Standards gaps and **duplications** of efforts

Inconsistent standards R&D across industries globally

No dedicated workforce to drive R&D for standards development

Lack of global acceptance of standards


America Makes
ANSI
Standardization Roadmap for
Additive Manufacturing
VERSION 2.0
PREPARED BY THE
America Makes & ANSI Additive Manufacturing
Standardization Collaborative (AMSC)
JUNE 2018

- 93 AM Standardization gaps
- 65 gaps need R&D

ASTM AM Center of Excellence (CoE)

CENTER of EXCELLENCE Research to Standards
ADDITIVE MANUFACTURING

Why ASTM create the AM CoE?

About the CoE

Rationale:

- Critical need to support development of globally accepted AM standards due to large gaps
- Critical need to educate the next generation of AM professionals and implementation of standards

Objective:

- To coordinate and conduct R&D that supports AM standards development
- To support related education, training and other programs

Expected outcome: AM standards via committees and standards related products and services

- Reducing time-to-market
- Increasing widespread adoption

CoE relation with respect to F42 Committee: ***F42 membership and other committees can leverage AM CoE as a platform*** to conduct research that can fill gaps in ongoing standardization efforts

Mission

The Center bridges standards development with R&D to better enable efficient development of:

- Standards
- Education and training and
- Certification and proficiency testing programs

Vision

The Center facilitates collaboration and coordination among government, academia, and industry to:

- Advance AM standardization
- Expand ASTM International's and our partners' capabilities.

Role of AM CoE with respect to F42

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ASTM Committee F42

Dedicated to AM and has technical subcommittees focused on the **development of consensus-based standards.** **This is happening in partnership with ISO TC261.**

ASTM AM CoE

A collaborative partnership among ASTM and organization representing government, industry, and academia that **conducts strategic R&D to advance standards across all aspects of AM** **in addition to create E&WD and Certification Programs.**

Platform for F42 members and AM community

- AM CoE is a platform that F42 members can tap into to conduct research to fill gaps in the AM standards.
- AM CoE is also a platform open for other ASTM technical committees to utilize resources.

Focal point for standard-related R&D activities

- AM CoE houses and facilitates AM R&D generation to support global standardization efforts

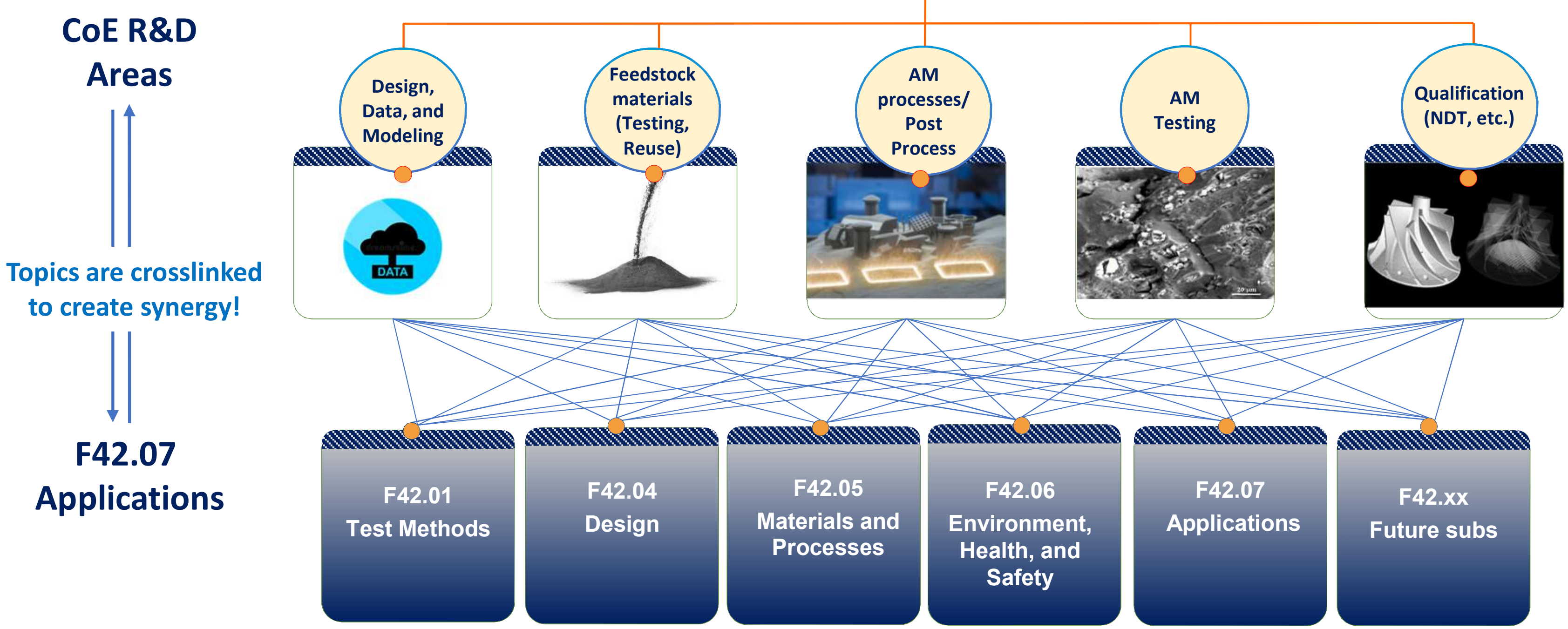
Global hub for AM innovation to support standardization

- Create strong national and international industry-government-university partnerships;
- Develop education, training, proficiency testing, and certification programs; and
- Host ASTM committee related events, workshops, and symposia.

AM CoE R&D: High Priority Areas

CENTER of EXCELLENCE Research to Standards
ADDITIVE MANUFACTURING

AM CoE R&D Themes



1. Defined based on the input of the CoE R&D team
2. Short-term
3. Highly-focused
4. High-priority (linked to AMSC roadmap and Committee F42)
5. Aligned with America Makes projects
6. Coordination/collaboration with NIST

Key highlights of the AM CoE

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Progress to date: R&D projects

The AM CoE follows a structured process to develop R**&D projects that align with high-priority gaps, challenges, and standards needs identified by the AMSC Roadmap**.

First Round of Projects: 2018 to 2019

LAUNCHED 5 Research Projects | ADDRESSING 13 Standards Gaps | IMPACTING 16 Existing Standards

	Project	Gaps	Standards
AU	METALLIC AM TESTING	3	3
EWI	POST PROCESSING	3	1
mtc	FEEDSTOCK	5	3
NASA	PROCESS QUALIFICATION	2	4
NIAR	NON-METALLIC AM TESTING	2	7

amcoe.org

Second Round of Projects: 2019 to Present

LAUNCHED 9 Research Projects | ADDRESSING 20 Standards Gaps | IMPACTING 11 Existing Standards

	Project	Gaps	Standards
NASA	LB-PBF PROCESS QUALIFICATION	9	1
NAMIC	DESIGN GUIDES FOR AM PROCESSES	1	2
mtc	DESIGN GUIDE FOR POST-PROCESSING	1	1
NIAR	POLYMER AM TESTING FOR PART PERFORMANCE	1	1
AU	RAPID QUALITY INSPECTION SPECIMEN	7	1
NIAR	POLYMER AM TESTING	1	1
NAMIC	IN-PROCESS MONITORING	1	1
mtc	POWDER FEEDSTOCK	4	2
EWI	DATA PEDIGREE	1	1

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Research & Development

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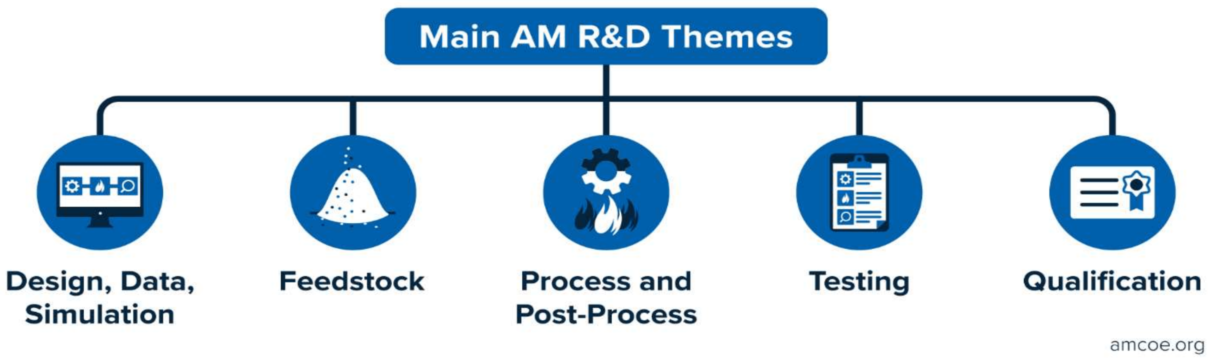
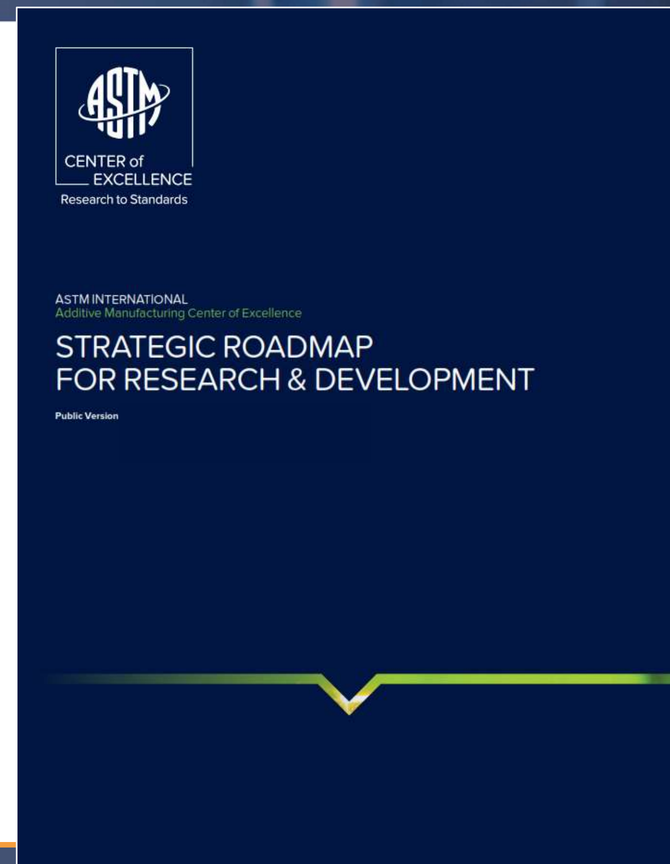
Public R&D Roadmap Objectives

- Communicate the **goals and current progress** of the AM CoE's R&D program
- Provide a **common vision for AM R&D's future** for the AM community to work toward

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Research to Standards

ASTM INTERNATIONAL
Additive Manufacturing Center of Excellence

STRATEGIC ROADMAP
FOR RESEARCH & DEVELOPMENT

Public Version

Education and Workforce Development (E&WD)

CENTER of EXCELLENCE
Research to Standards
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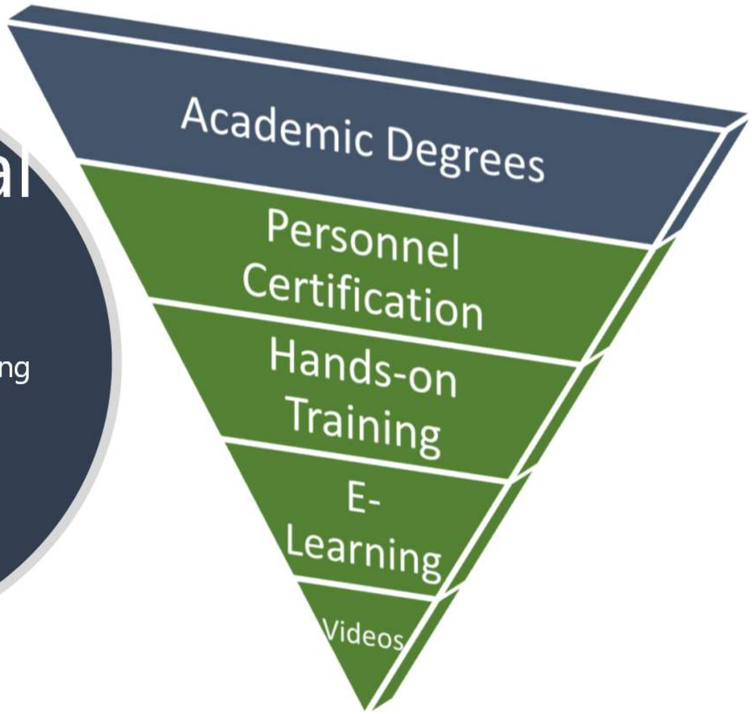
Mission Statement

"To provide a **comprehensive program that educates and trains the additive-manufacturing workforce at all levels,** while continually incorporating new advances, responding to industry needs, and leveraging standardization, certification, and our partners' expertise."

E&WD Initial Goals

- ✓ Establish Education & Training Strategy
- ✓ Establish business model
- ✓ Design and schedule first branded course



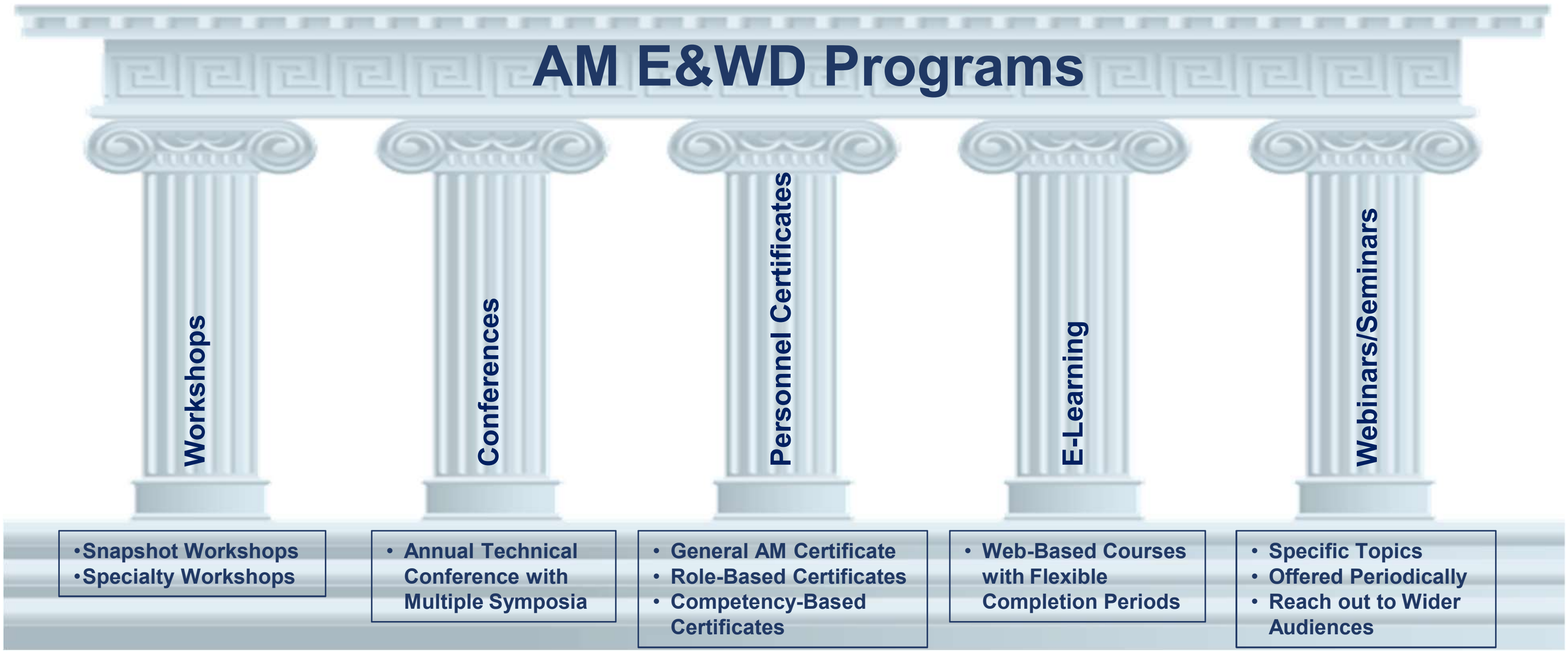
E&WD Team

Mohsen Seifi (ASTM International; **Khalid Rafi** (ASTM), **Nima Shamsaei** (Auburn University); **Jeff Suhling** (Auburn University); **Mike Ogles** (Auburn University); **Martin Dury** (MTC); **Lee Gallimore** (MTC); **Colin Bancroft** (MTC), **Paul Jonas** (NIAR); **Rachael Andrulonis** (NIAR)

Education and Workforce Development (E&WD)

CENTER of EXCELLENCE
Research to Standards
ADDITIVE MANUFACTURING

Major Pillars of E&WD Program



E&WD Program Strategy - Timeline

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2020

1. AM Personnel Certificate Program
2. AM Webinar Series
3. AM safety Training Program
4. Connect with Machine OEM's about providing training

2021

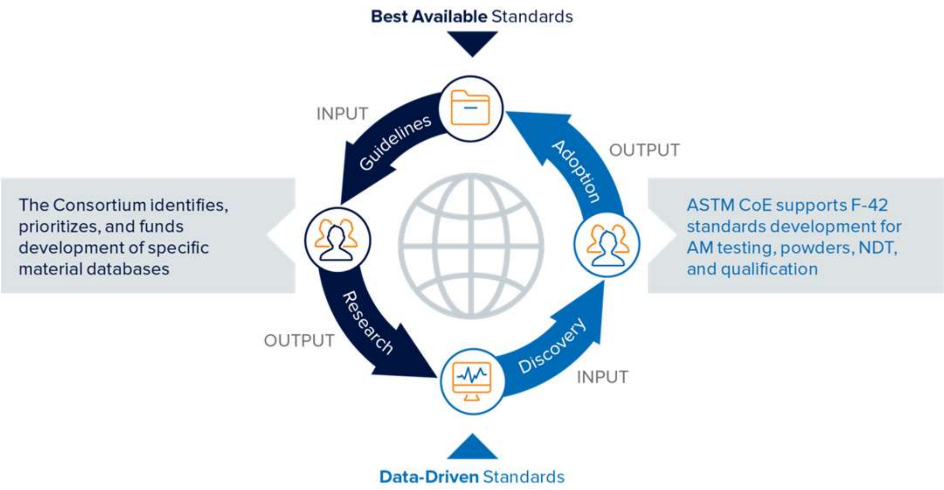
5. Revise, update, and Continue programs from 2020
6. Role-based Certificate Programs
7. E-Learning Programs
8. ASTM Approved Training Provider (AATP)
9. Europe and Asia Expansion
10. Provide targeted safety training in partnership with machine OEM's

2022

11. Revise, update, and continue Programs from 2020 and 2021
12. Industry specific training programs
13. Train-the-trainer/licensing
14. Engagement with Universities

Industry Consortium

- Data is one of the big challenges for AM
  - Cost – Data is very expensive
- Industry Consortium Value
  - Member exclusive design allowable data sets with ROI 5:1
  - Aim to create data that can be used for standard development
  - Leverage expertise from EWI, Auburn University, NASA, and NIAR
  - Partnership with Battelle for data analysis



How can you get involved?

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The AM CoE offers several mechanisms to help you get involved.

01 Upcoming Call for **R&D Projects** (CFP)

02 Participation in **“Work Items”** that AM CoE is contributing to and/or initiating

03 Upcoming **CoE events**

04 **Other mechanisms** are being developed and considered (Any suggestions are welcome.)

ICAM 2020

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17 Symposium topics

10 AM related topics	7 Application topics
1. Structural Integrity	1. Construction
2. i4.0	2. Maritime and Oil & Gas
3. Feedstock	3. Electronics
4. Ceramics	4. Medical
5. Polymers	5. Aviation and Spaceflight
6. Microstructure	6. Transportation/Heavy Machinery
7. NDE	7. Defense
8. Fatigue	
9. Mechanical testing	
10. General	

325+ Talks | 20+ Countries | 60+ Organizing Committee

Q&A

Dr Mohsen Seifi: mseifi@astm.org
Dr Martin White: mwhite@astm.org
www.amcoe.org

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Thank you for your attention!

PRESENTATION 15

American Nuclear Society

ANS Activities Related to Advanced Reactors

by

Dr. George Flanagan
Chairman of the ANS Research and Advanced Reactors Consensus Committee (RARCC)

RARCC Activities

- In addition to the ASME/ANS PRA standards discussed earlier
- ANS has five standards under development that directly relate to specific advanced reactors
  - ANS 30.1
    - Integrating Risk and Performance Objectives into New Reactor Nuclear Safety Designs
  - ANS 53.1
    - Nuclear Safety Design Process for Modular High Temperature Reactors
  - ANS 54.1
    - Nuclear Safety Criteria and Design Process for Sodium Fast Reactor Nuclear Power Plants
  - ANS 30.2
    - Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants
  - ANS 20.2
    - Molten Salt Reactor Nuclear Safety Criteria and Design Process

A1

Slide 2

A1 Author, 6/17/2020

It has taken far too long for the development of these standards

ANS 53.1 took over 10 years

ANS 54.1 took over 10 years

ANS 30.1 has taken over 4 years and is not finished

ANS 20.2 has is just getting started and is approaching first ballot currently over 3 years

ANS 30.2 has not started even though it's PINS was approved more than two years ago.

Challenges

- Developers may be concerned that the time required to develop the necessary codes and standards may impact project schedules
- In some cases, SDOs and advanced reactor developers may not have resources to commit to fully develop the desired codes and standards on the timelines needed
  - Lack of resources: voluntary activity, not part of staff's everyday activities
  - Much of the information needed comes from earlier work by DOE which resides at national laboratories-limits number of staff
- Information needed to support early development of standards may not be available

Opportunities

- DOE needs to recognize that the development of standards is a part of the advanced reactors program
- Diversity of designs hinders the development of a standard that benefits all developers (how to protect IP)
- Important that developers understand and recognize the importance of standards over the long term and encourage their staff and DOE to develop such standards
- Developers need to identify the need and priority for new standards in their area

QUESTIONS?

PRESENTATION 16

DOE Standards Executive Perspective on Barriers to Effective Standards Development

Garrett Smith
Director
Office of Nuclear Safety

Office of Environment, Health, Safety and Security

The Office of Nuclear Safety…

…develops and maintains DOE specific Policy, and requirements for nuclear safety basis, facility design, nuclear safety management programs, Quality Assurance and nuclear material packaging.

We seek to strengthen cooperation, expand our technical competence, and be a change agent for more effective and efficient nuclear safety and quality assurance policy.

DOE Realities

- DOE is both the Owner **and** the Regulator for a large fleet of nuclear facilities.
- DOE is building new nuclear facilities.
- DOE facilities are often unique and one-of-a-kind (Standardization is a challenge).
- DOE policies / standards rely consensus standards.
    - Over 145 active DOE Standards and Handbooks and 2000 adopted Voluntary Consensus Standards

Our Obligations under OMB Circular No. A-119

- Agency support provided to a voluntary consensus standards activity must be limited to that which clearly furthers agency and departmental missions, authorities, priorities, and is consistent with budget resources.
- Agency employees who, at Government expense, participate in standards activities of voluntary consensus standards bodies on behalf of the agency must do so as specifically authorized agency representatives.
- Agency Standards Executive -- to the extent possible, ensuring that the agency's participation in voluntary consensus standards bodies is consistent with agency missions, authorities, priorities, and budget resources.

A Little Different View -Barriers and Challenges

- Sustainability and Timing – efforts that take years often loose some relevancy and momentum. Non-consensus standard alternatives are pursued.
- Consensus process is imperfect. Relies on volunteers, schedule slips common, level of detail sometimes requires significant resources for implementation guidance, lowest common denominator.
- Safety approval authority buy-in essential. Contentious issues not resolved during consensus process subject to add-ons.

A Little Different View -Barriers and Challenges (cont'd)

- Structural reform of Committee / SubCommittee process may be needed –at least it needs to be examined.
- Funding and Prioritization essential. Research activities needed to be tightly focused and held to a meaningful and timely schedule. Willingness to re-evaluate and change or stop activities essential when efforts do not yield results.

PRESENTATION 17

INFRASTRUCTURE

MINING & METALS

NUCLEAR, SECURITY & ENVIRONMENTAL

OIL, GAS & CHEMICALS

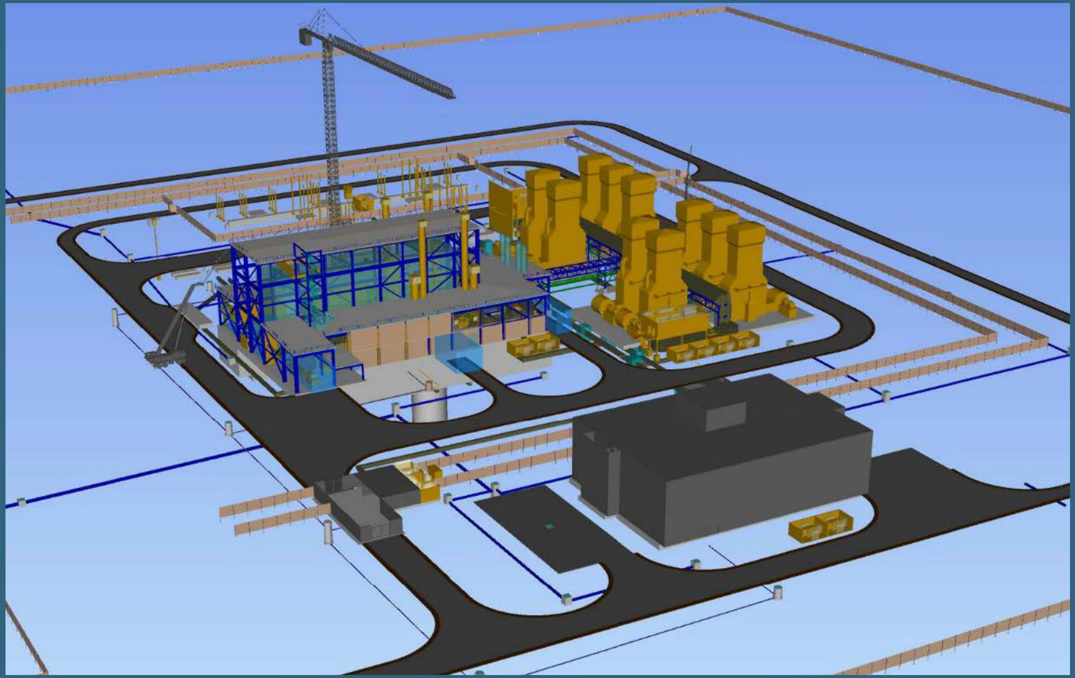
NEI-ANS Advanced Reactor Codes & Standards Workshop

Panel Discussion:
Addressing Barriers to Standards Creation

Chip Lagdon

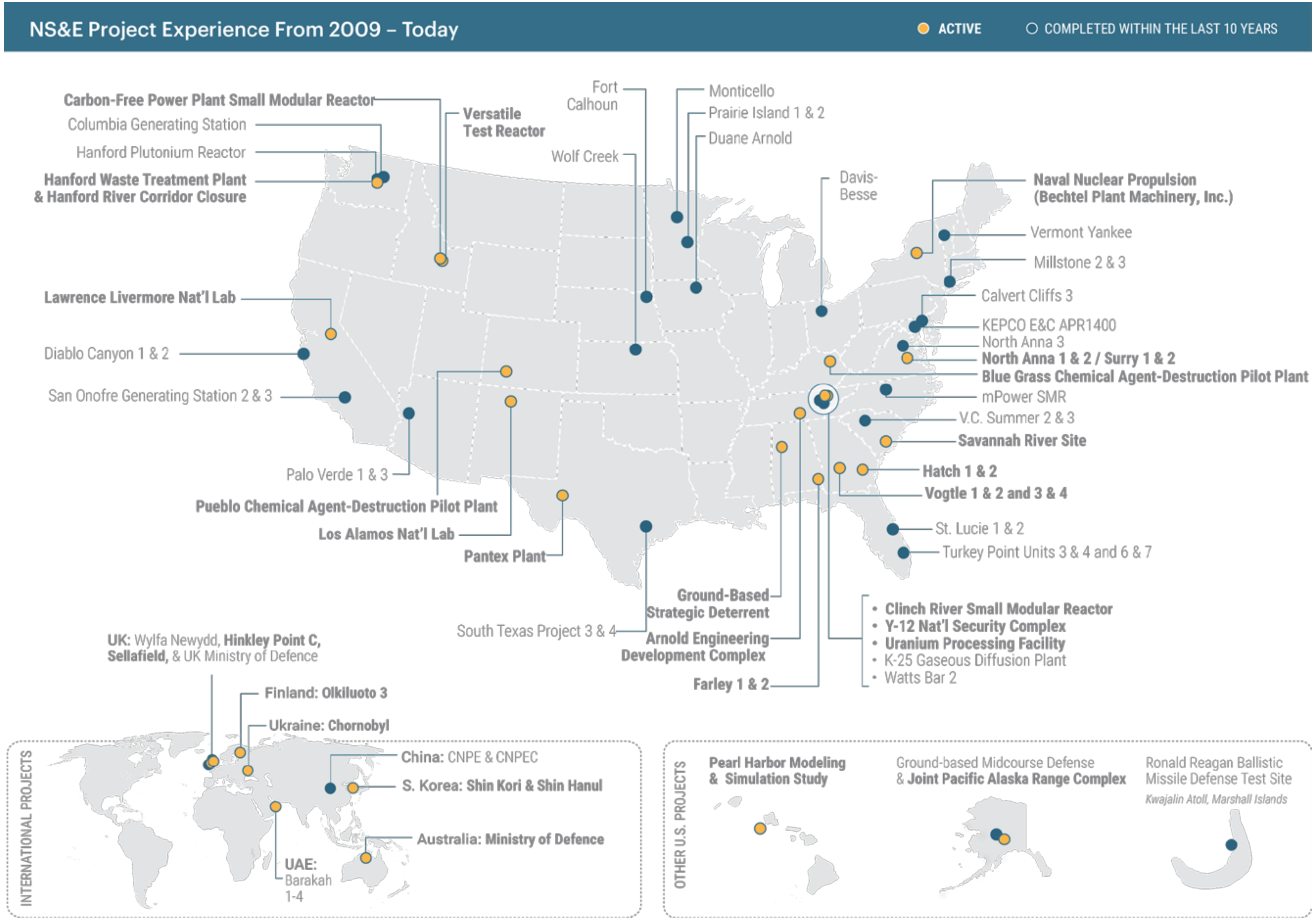
Chief Engineer, Nuclear Safety and Operations

June 23, 2020



Current and Recent Nuclear Projects

- Vogtle Units 3&4 Construction Completion
- Versatile Test Reactor Engineering Design at Idaho National Laboratory
- Uranium Processing Facility at Y-12 Nat’l Security Complex
- Hanford Waste Treatment Plant
- Advanced Reactor Support – 4 DCAs, 9 COLAs, 4 ESPAs for 5 advanced reactor technologies including AP1000, ABWR, ESBWR, APR1400, EPR, and SMRs
- Utility EOC and Post Fukushima Support – Southern Nuclear, Dominion, STPNOC, Exelon, FENOC



An Example: An ASME Code for Steel Plate Composite (SC) Containment Vessel

- Steel-plate composite (SC) applications are identified for most advanced reactor designs
- For the application of SC construction to containment structures, NEI 19-03, Advanced Reactor Codes and Standards Needs Assessment, noted the following as a high priority need (underlined text identifies the relevant ASME codes):
  - *Changes are necessary to address the varied advanced reactor designs as well as functional containment concepts. Updates* <u>*(to ASME BPVC Section III Division 1, Subsection NE, and/or to Division 2, Containment)*</u> *should consider including steel-plate composite (SC) construction for containment structures. Note that AISC N690 allows for SC walls for safety-related structures other than containment.*
- The geometry and functions of an advanced reactor containment structure could differ from that for a traditional light water reactor
- Bechtel and others, along with Purdue University, have initiated a dialog with ASME for exploring the right approach for introducing design and construction provisions for SC containment structures (i.e., by either making changes to an existing ASME code or by developing a new code)
- Bechtel and Purdue have already performed some research in this field (as have some Japanese researchers)… The Bechtel-Purdue team is currently working with EPRI to secure funding for further research and codification efforts for SC containment structures

Other SC Construction Topics for Advanced Reactor Applications

- Advanced reactor applications involve some new frontiers/wish-list items for SC applications:
  - Exposure of SC structural elements to high temperatures
  - Underground structures, where exterior SC walls will be in contact with soil and groundwater
  - Strong push for use of modular SC-based floor systems
- These topics need to be addressed in a future edition of AISC N690 (as well as in the future ASME code provisions for SC containment structures)
- Bechtel and Purdue researchers are working with EPRI to secure funding for the necessary research and codification efforts
- Bechtel researchers are developing modular SC-based foundation systems; such foundations could be used for a variety of nuclear facilities (as well as for other industrial and commercial facilities)
- Where appropriate and feasible, the SC-based foundation modules may be prefilled with lightweight concrete
- Eventually, new ACI code provisions will need to be developed for SC-based foundation systems

Addressing the Barriers to Standard Creation & Possible Prioritization

- Code Committee work is becoming increasingly difficult for companies to invest resources
- Code work is often performed on a voluntary basis
- Voluntary standards development may not be timely to support
  - Licensing
  - Specific designs
  - Construction
- Opportunities exist to develop a practical approach to funding and prioritization

Addressing the Barriers to Standard Creation & Possible Prioritization *(continued)*

DOE Regulatory Approach

- Project Management Processes require safety design strategy which can help identify needed standards at Conceptual Design
- DOE uses a mix of internal and National Standards
- Standards development can then be tied to Critical Decision processes for Design Complete, Construction and Operations
- Development includes identification of existing standards and gaps
- Technology Readiness Levels to establish priorities

NRC Licensing Approaches

- Advanced reactors will use the 10CFR50 and 10CFR52 Licensing Approaches
- RG 1.233, Guidance for Non-Light-Water Reactors endorses NEI-18-04 and these provide foundational expectations
- NRC's Advanced Reactor Policy encourages earliest possible interaction of applicants, vendors, government agencies and the NRC to provide early identification of requirements…. This could include identification of standards needed as means of aiding prioritization
- A Safety Design Strategy could be helpful for an advanced reactor in demonstrating application of NEI 18-04 and RG 1.233 and standards needs

Contact Information

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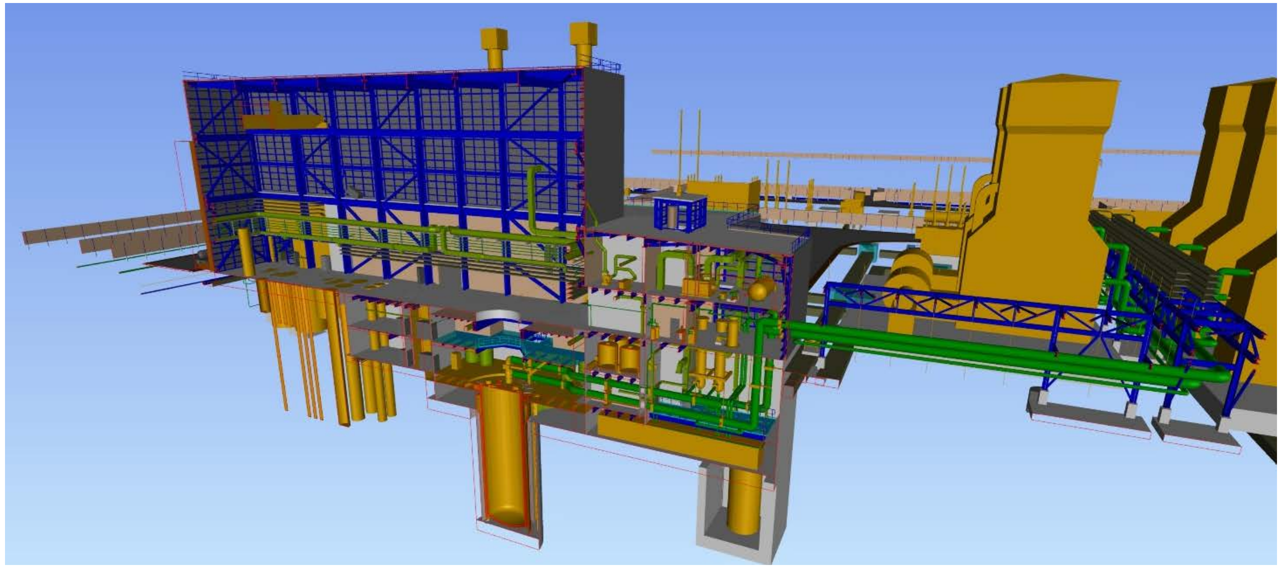
Bechtel National, Inc. | 12011 Sunset Hills Road, Reston, VA 20190

Email: rhlagdo1@bechtel.com



Versatile Test Reactor (VTR) 3D Model

Vogtle Unit 3 Shield Building Roof Placement

Learn more about Bechtel by visiting us online at http://www.bechtel.com

PRESENTATION 18

NUSCALE™

Power for all humankind

Barriers to Standards Development

June 23, 2020

Kent Welter, Ph.D.
Chief Engineer, Testing and Analysis

Acknowledgement and Disclaimer

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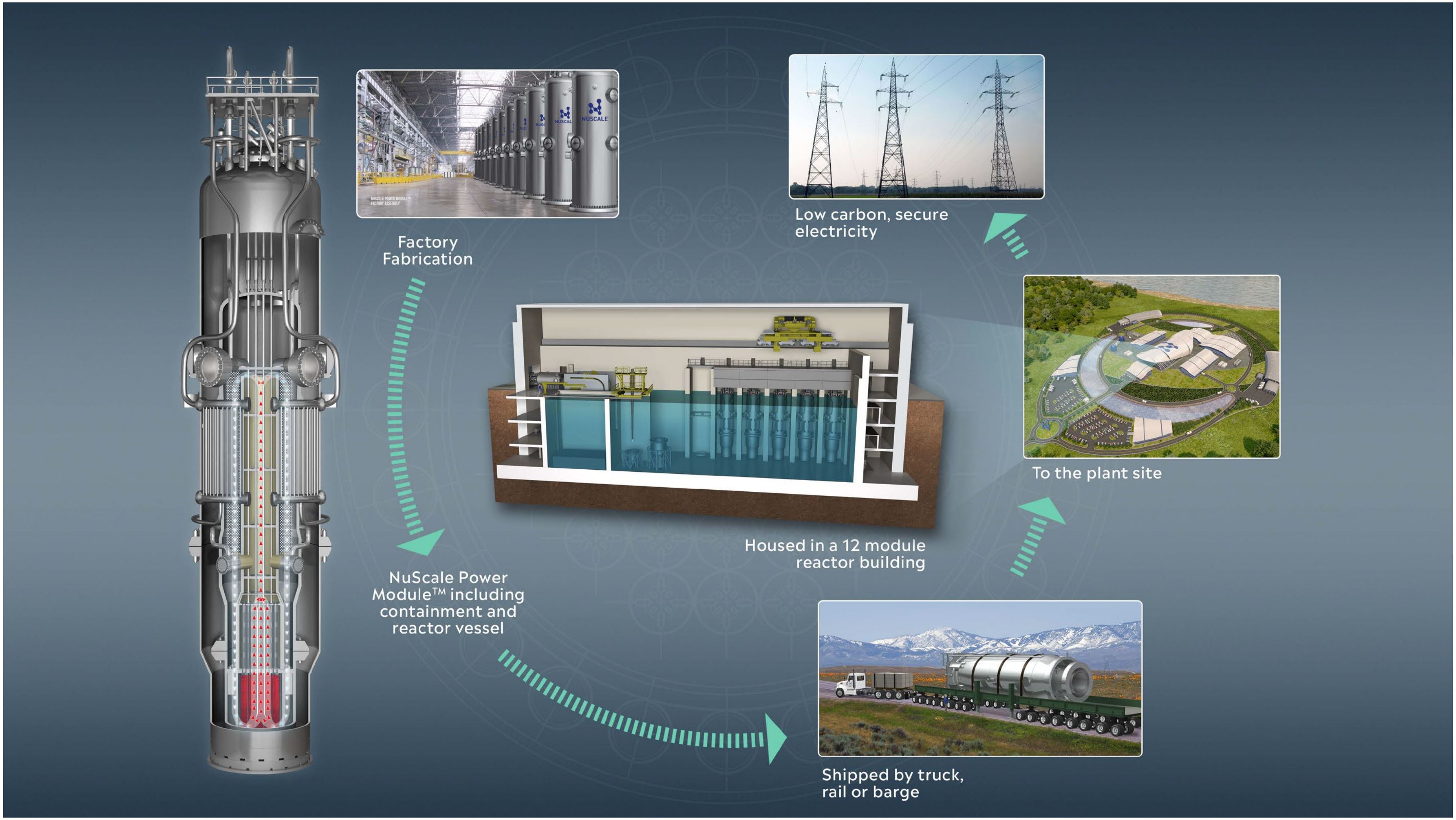
NUSCALE™
Power for all humankind

NuScale's Mission

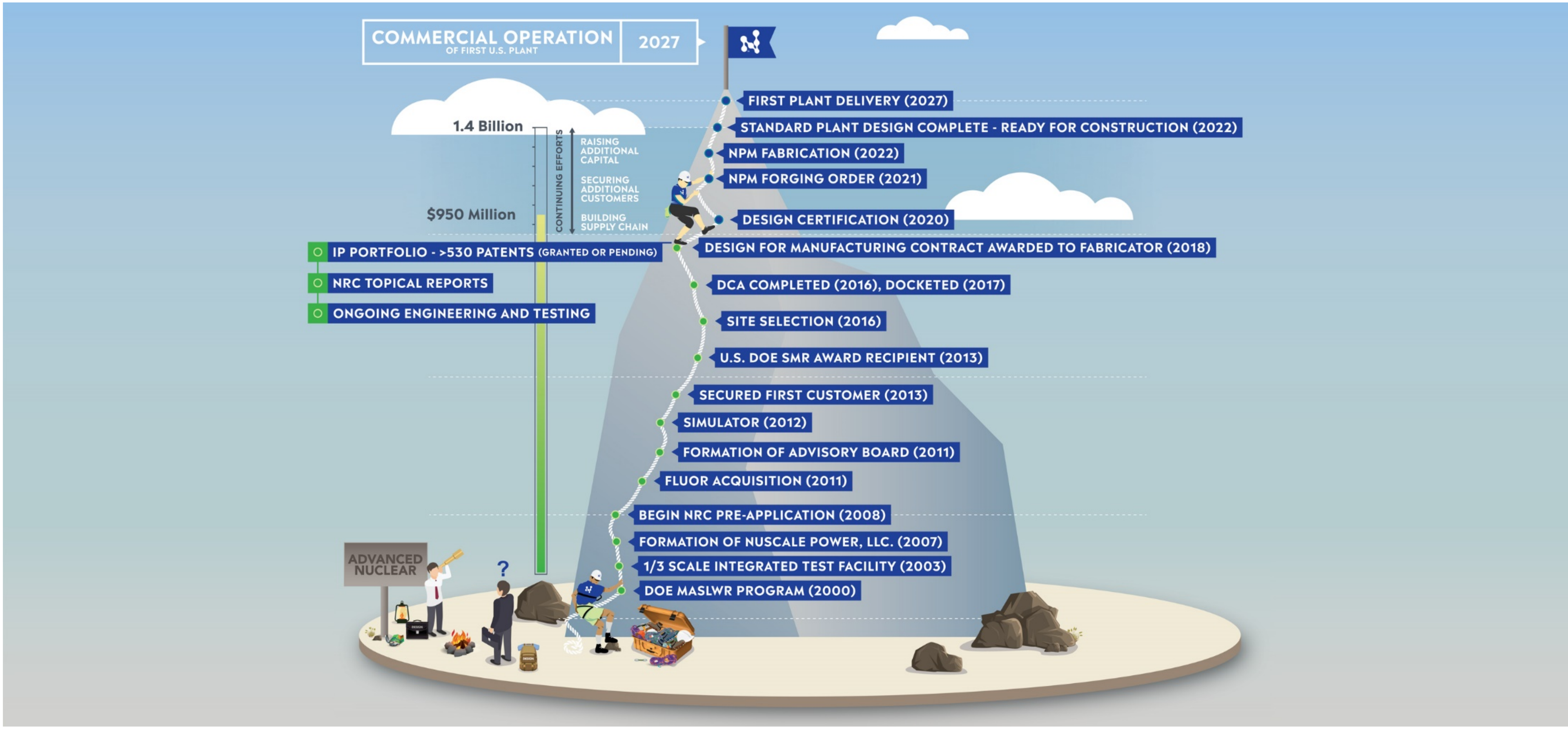
NuScale Power provides scalable advanced nuclear technology for the production of electricity, heat, and clean water to improve the quality of life for people around the world.

Artistic concept of the NuScale Power Plant

A New Approach to Construction and Operation



Blazing the Trail to Commercialization



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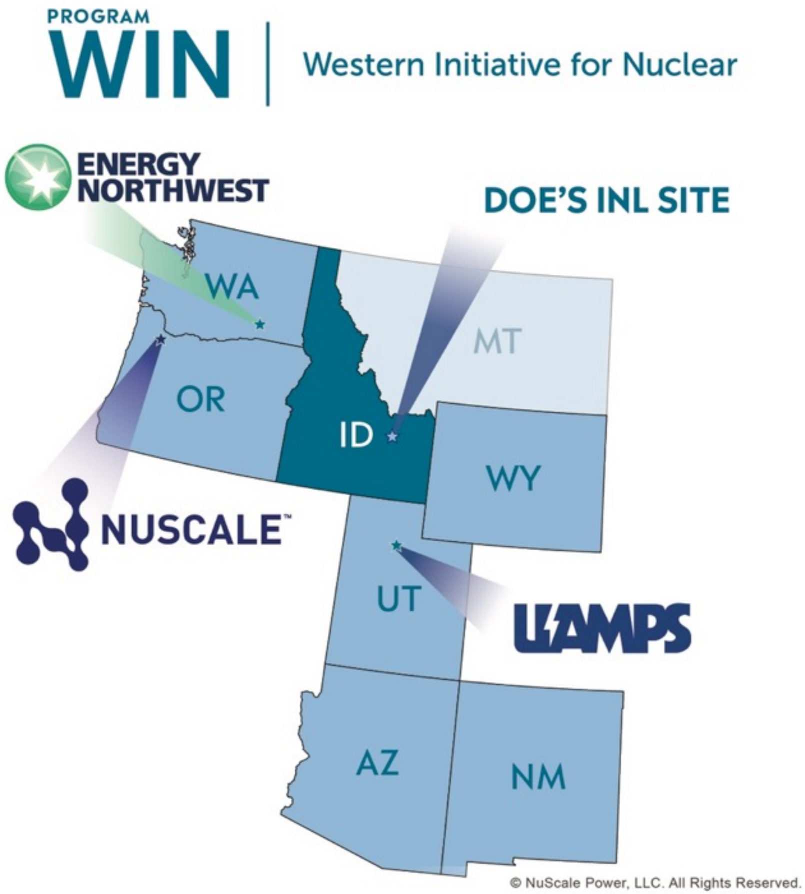
First Deployment: UAMPS Carbon Free Power Project



- Utah Associated Municipal Power Systems (UAMPS) provides energy services to community-owned power systems throughout the Intermountain West.
- First deployment will be a 12-module plant (720 MWe) within the Idaho National Laboratory (INL) site, slated for commercial operation in 2027.
- DOE awarded $63.3 million in matching funds to perform site selection, secure site and water, and prepare combined operating license application to NRC and advance the site specific design.
- Joint Use Modular Plant (JUMP) Program: INL-DOE will lease one of the modules in the 12-module plant, for research purposes, an additional module may be used in a Power Purchase Agreement (PPA) to provide power to INL.

NUSCALE™ Power for all humankind

NuScale participation in standards development

- Significant involvement in ASME pressure vessel codes and standards (15+ NuScale staff)
- Chairing several ANS/ASME standards related to advanced light water reactor risk-informed performance-based design
- Active involvement with IEEE standards related to safety criteria and human factors engineering

Barriers to standards development

- Too many groups trying to do the same thing with minimal effective coordination
- Too many reviewers and commenters. Maybe need to redefine consensus?
- Lack of curiosity / support for adoption of new technologies and techniques
- Understanding of why existing standards were written the way they were
- Ability to support extension of existing standards to new technologies
- Attracting and retaining next generation of engineers and scientists for standards development
- Continuity of knowledge amongst standards members / developers
- Lack of regulator involvement, turnover, or changes in positions
- Lack of funding for basic research and sharing of results (i.e., proprietary)

PRESENTATION 19

Advanced Reactor Codes and Standards – GEH Needs and Priorities Supporting Future Reactor Designs

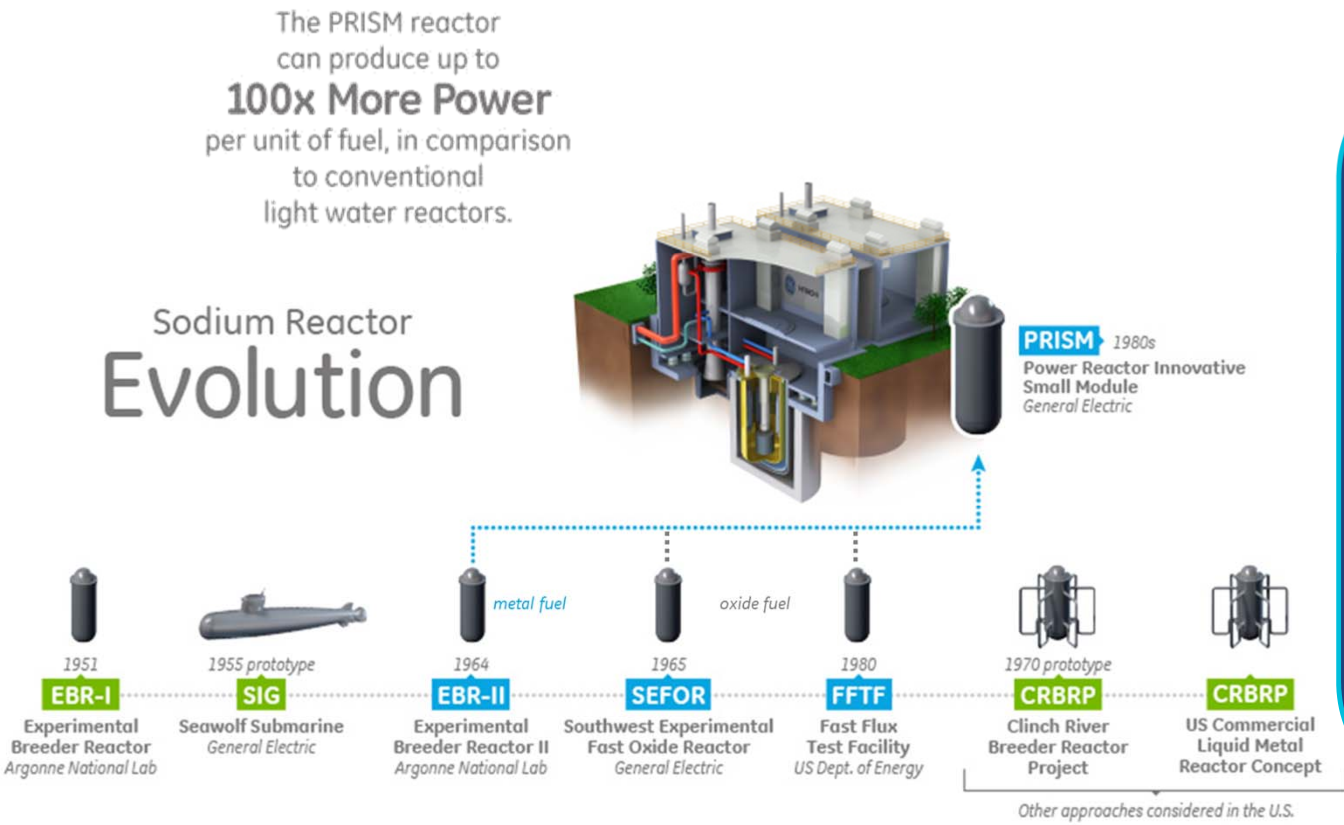
NEI-ANS Advanced Reactor Codes and Standards Workshop
June 23, 2020

Michael Arcaro
GE Hitachi Nuclear Energy
Principal Engineer – Systems Engineering

Identification of Codes & Standards Priorities for Advanced Reactor Designs

- GEH is active in advancing Codes & Standards applicable to Sodium Fast Reactor (SFR) technology
    - Priority SFR Codes and Standards are accelerated
- GEH is active in advancing advanced Light Water Reactor (LWR) Small Module Reactor (SMR) technology
    - Priority LWR Codes and Standards are accelerated
- Codes and Standards for technology that reflect risk and uncertainty

Sodium Fast Reactor Solution - PRISM



- Sodium cooled fast reactor … Gen IV
- 165 and 311 MWe options
- Compact pool-type … atmospheric pressure, eliminates LOCA
- Passive safety … air cooling
- Proven metal fuel … inherently safe
- Superheated steam … plant efficiency
- Modular design … quality & efficiency
- High temperature … industrial process heat applications
- Advanced Recycling Center application … 99% fuel utilization

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Codes & Standards Priorities for SFR Advanced Reactor Designs

❖ Advance ASME III Division 5, High Temperature Reactors

- Extend the qualified lifetimes of Class A materials to support a 60- year design life
- Develop analysis methods to simplify the Division 5 design
- Develop loading and cyclic stress-strain curves for Division 5 materials
- Develop improved design methodology for creep-fatigue evaluation by analysis for BPV III-5 to take full advantage of modern analysis tools, such as elastic-plastic finite element analysis with creep strain capability

❖ ASME Section XI, High Temperature ISI

- ASME CC N-875, Alternative Inservice Inspection Requirements for Liquid Metal Reactor Passive Components, Section XI, Division 3, IMB-2500

❖ ASME QME-1, Qualification of Active Mechanical Components

- Address advanced reactor design components and HT applications to correspond to Section III, D1

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Codes & Standards Priorities for SFR Advanced Reactor Designs (cont.)

❖ ANS 54.8, Liquid Metal Fire Protection in LMR Plants [W]
- Requirements and guidelines associated with sodium fire protection

❖ ANSI/ANS-54.1 [R], Nuclear Safety Criteria and Design Process for SFR NPPs
- Topics such as PRA Scope / Capability, Identification of LBEs, Selection Criteria

❖ ANSI/ANS-58.14, Safety /Pressure Integrity Classification Criteria For LWR
- Basis to be used to develop a graded quality approach for non-LWR systems

❖ Requirements for Reliability and Integrity Management (RIM)
- SFR design will benefit from advancing RIM by moving away from visual inspection of sodium wetted SSC to system based code requirements
- Due to lack of corrosion under sodium VTM-3 (e.g. dimensional gauging) inspection value is low
- Article VII-2, Supplement for Liquid Metal Reactor-Type Plants (In Course of Preparation – Completion Expected for Publication in the 2021 Edition)

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BWRX300

- 10th generation BWR … 300 MWe SMR
- World class safety
- Targeting LCOE competitive with gas
- Significant capital cost reduction per MW
- Constructability integrated into design
- Scaled from licensed ESBWR
- Designed to mitigate LOCA
- Reduced on-site staff and security
- Design-to-cost approach: targeting <$1B total and <$2,250/kW
- Capable of load following to operate with high penetration of renewable generation
- Ideal for industrial applications … district heating and desal
- Initiated licensing in the U.S. and Canada

Deployable by 2027

Codes & Standards Priorities for Advanced LWR SMR Reactor Designs

Containment Structure- ASME III Division 2, Containment

- Expand Div. 1 NE / Div. 2 CC to include steel-plate composite (SC) construction for containment structures
- AISC N690 allows SC walls for safety related structures other than containment

ASCE Codes

- Provide clarity on analysis and design of deeply embedded structures
  - Seismic aspects added to ASCE 4, ASCE 43, and/or ANS 2.29
- Expand ACI 349 and AISC N690 to provide correlation of ductility limits for impact impulsive forces to inelastic energy absorption factors considered in seismic design

ASME III, Div. 1 Components

- Advanced autogenous (no weld filler) weld processes
- EB, Laser, Friction, Diffusion Bonded -simplify shop/field fab & reduce inspect requirements

ASME Section II, V and IX

- Changes in material specs (powdered metals, cermets), welding quals (new methods), acceptance of new welding methods (AM, EB welding, laser welding)

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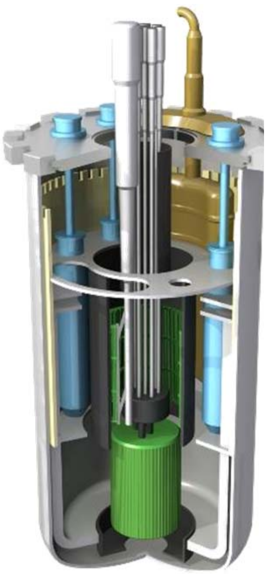
GEH Input on Low Priority Codes and Standards

PRISM



1 **ANS 30.1. Integrating Risk and Performance Objectives into New Reactor Safety Designs**

GEH has direction under existing risk and performance evaluation methods including PRA and views development of ANS 30.1 as a low priority activity

GEH SFR offerings are utilizing the Licensing Modernization Process (LMP) as outlined in NEI 18-04

2 **ANS-30.2, Categorization and Classification of SSCs**

This standard provides a single technology neutral categorization and classification process for SSCs for advanced reactors that is, where possible, RIPB. This process will then be used to determine special treatment of SSCs to meet the safety basis

GEH has direction under existing SSC categorization and classification processes and views development of ANS 30.2 as a low priority activity

BWRX-300

1 **ANS 30.1. Integrating Risk and Performance Objectives into New Reactor Safety Designs**

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GEH LWR SMR offerings utilizing IAEA methods of assessment

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PRESENTATION 20

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC Perspectives and Role in Advanced Reactor Codes and Standards

NEI-ANS Advanced Reactor Codes and Standards Workshop

Louise Lund, NRC Standards Executive
Director, Division of Engineering
Office of Nuclear Regulatory Research

June 23, 2020

Legal and Policy Framework

National Technology Transfer and Advancement Act of 1995

PUBLIC LAW 104–113—MAR. 7, 1996 110 STAT. 775

OMB Circular A-119

EXECUTIVE OFFICE OF THE PRESIDENT
Office of Management and Budget

NRC Management Directive 6.5

U.S. NUCLEAR REGULATORY COMMISSION MANAGEMENT DIRECTIVE (MD)

MD 6.5	NRC PARTICIPATION IN THE DEVELOPMENT AND USE OF CONSENSUS STANDARDS	DT-17-141
Volume 6:	Internal Management	
Approved By:	Michael Weber, Director Office of Nuclear Regulatory Research	
Date Approved:	October 28, 2016	
Cert. Date:	N/A, for the latest version of any NRC directive or handbook, see the online MD Catalog.	
Issuing Office:	Office of Nuclear Regulatory Research Division of Engineering, Regulatory Guidance and Generic Issues Branch	
Contact Name:	Kurt Cozens	

EXECUTIVE SUMMARY

Management Directive (MD) 6.5, "NRC Participation in the Development and Use of Consensus Standards," provides direction for implementing the National Technology Transfer and Advancement Act of 1995 (Public Law 104-113) and the Office of Management and Budget Circular No. A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities." This revision—

- Establishes new roles and responsibilities, including the Standards Steering Committee, Technical Forum, Program Manager, and Standards Development Organization (SDO) coordinator.
- Clarifies the roles and responsibilities for and NRC representatives to SDO committees.
- Eliminates the roles and responsibilities for the Chief Information Security Officer.
- References a new guidance document that contains detailed implementation steps, previously contained in the handbook, and cites additional implementation guidance.
- Updates the references cited in MD 6.5.

For updates or revisions to policies contained in this MD that were issued after the MD was signed, please see the Yellow Announcement to Management Directive index (YA-to-MD index).

Nuclear Energy Innovation and Modernization Act

PUBLIC LAW 115–439—JAN. 14, 2019 132 STAT. 5565

Public Law 115–439
115th Congress

An Act

To modernize the regulation of nuclear energy.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NRC Codes & Standards Program Activities

- NRC is actively participating in the development and use of consensus codes and standards across multiple Standards Development Organizations (SDOs).
- Codes and standards improve effectiveness and efficiency of regulatory oversight.
- NRC Management Directive 6.5:
  - identifying and prioritizing the need for new and revised technical standards
  - participating in codes and standards development
  - endorsing codes and standards.

Endorsement of Standards

- Staff participation in codes and standards development enhances the effectiveness and efficiency of the endorsement process.
- NRC may add exceptions or conditions to standards.
- SDOs are encouraged to notify the NRC of new or revised standards.

Non-LWR Implementation Action Plan Progress Summary (SECY-20-0010)

- Strategic Area No. 4: Consensus Codes and Standards
  - Supports the objective of enhancing non-LWR technical readiness and optimizing regulatory readiness.*
  - NRC is actively participating and supporting codes and standards development activities, including:
    - ASME B&PV Code, Section III, Division 5
    - ASME Qualification of Active Mechanical Equipment (QME) Committee
    - American Nuclear Society (ANS) Standards
    - ASME/ANS Non-LWR PRA Standard

*Codes and Standards improve effectiveness and efficiency of regulatory oversight. Developers can proceed in the absence of Standards with adequate basis supporting their designs.

ASME Standards

- ASME B&PV Code, Section III, Division 5
  - The staff plans to endorse via new Regulatory Guide (RG)
    - Technical basis document (staff NUREG report) under development.
- ASME Qualification of Active Mechanical Equipment (QME) Committee
  - NRC staff is working with the ASME QME Committee in the development of rules for active components operating at temperatures above 426 °C (800 °F).

ANS Standards

- NRC is currently participating on multiple ANS Standards Committees, including:
  - ANS 53.1, Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants
  - ANS 54.1, Nuclear Safety Criteria and Design Process for Liquid-Sodium-Cooled Nuclear Power Plants
  - ANS 20.2, Nuclear Safety Design Criteria and Functional Performance Requirements for Liquid Fuel Molten-Salt Reactor Nuclear Power Plants
  - ANS 30.1, Integrating Risk and Performance Objectives into New Reactor Nuclear Safety Designs
  - ANS 30.2, Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants

ASME/ANS Advanced Non-LWR PRA Standard

- The ASME/ANS Joint Committee on Nuclear Risk Management (JCNRM) is expected to issue a final version of the advanced non-LWR PRA Standard by December 2020.
- The staff plans to endorse the PRA standard with the development of a new RG, similar to RG 1.200.

Next Steps

- NRC to continue its participation on SDO activities for the development and or update of priority standards
- Continue gathering feedback from utility/vendors, standards development organizations, and other stakeholders on codes and standards needs and related near term activities
- Standards Forum – September 15, 2020.

QUESTIONS?

PRESENTATION 21

Initial Summary of Workshop Learnings and Takeaways

June 23, 2020

Summary of Learnings and Takeaways

- A key issue is how we identify and align on priorities and how to fund the highest priorities. Myriad of advanced reactor designs makes standards development more challenging
- Although resources may be a challenge for advanced reactor developers the best way to influence SDO activities is to be involved in the activities that are most important to them
- Advanced reactor developers emphasized the importance advanced reactor materials research and standards development as opposed to development of process standards. The lack of “state of practice” experience limits interest and inhibits progress in this area
- DOE programs (demonstration projects) that accelerate AR development and deployment need to support Codes & Standards development activities and accelerated timelines

Summary of Learnings and Takeaways(cont)

- For advanced reactor developers the timing of codes and standards development and endorsement is a key issue. Even for developers looking 5-10 yrs into the future this is seen as a challenge

- Trial Use / Pilot standards may be an opportunity that we need to use to get maximum benefit particularly in areas where the state of practice has not been fully developed

- It is beneficial to enhance the lines of communication with advanced reactor developers, DOE and Codes and Standards Organizations to fund research for advanced reactor materials that support codes and standards development

Summary of Learnings and Takeaways(cont)

- Does the infrastructure for codes and standards development need to adapt to better support advanced reactor development.
- Voluntary support of codes and standards development will likely not support the accelerated development needed for advanced reactors.
- Technology readiness levels could be utilized in prioritization of codes and standards development.
- Moving forward, key standards for which information is available and ranked high should receive additional resources, standards that require additional research (such as materials standards) should get the resources needed to gather the information needed to develop

Proposed Next Steps

- Code/Standard prioritization
  - NEI: bridge the gap between industry and SDOs
  - TWGs: develop priorities for codes/standards
  - SDOs: work with industry to understand capabilities
- Funding opportunities for code and standards development
  - DOE and GAIN: clarify/establish funding opportunities
  - Developers/SDOs: partner on proposals for funding specific code/standard development
- Regulatory acceptance
  - NEI/industry: work on processes for accelerating acceptance of codes/standards; process for licensing where no code/standard exists
  - NRC: prepare for code/standard acceptance, participate in development

