NRC Standards Forum

Advanced Nuclear Technology (ANT) Research and SDO Impact

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Senior Technical Leader

NRC Standards Forum
September 26, 2017

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  - Modern Technology Application
- List of projects with potential influence on standards (completed, active, future)
- Advanced Reactor Strategic Program

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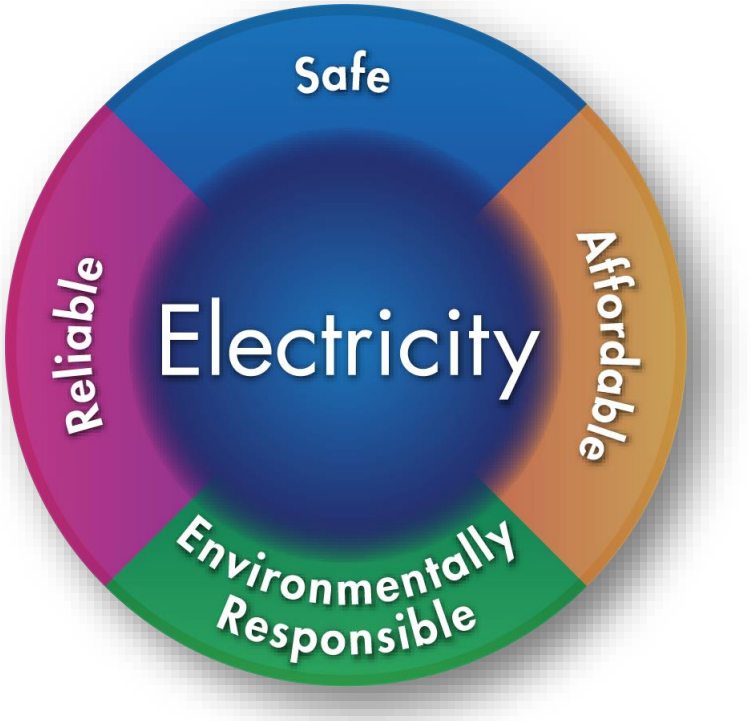
EPRI's Mission

Advancing ***safe***, ***reliable***, ***affordable,*** and ***environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation



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ELECTRIC POWER RESEARCH INSTITUTE

Conducting Research Today

Environment

- Environmental Sciences: Air and Multimedia
- Environmental Sciences: Groundwater and Land Management
- Environmental Sciences: Water and Ecosystems
- Strategic Analysis and Technology Assessments
- Workforce and the Public: Health Assessment and Safety
- Renewables
- Sustainability

Nuclear

- Advanced Nuclear Technology
- Chemistry and Radiation Safety
- Equipment Reliability
- Fuel Reliability
- Long-Term Operations
- Materials Degradation/Aging
- Nondestructive Evaluation and Material Characterization
- Risk and Safety Management
- Used Fuel and High-Level Waste Management

Generation

- Advanced Fossil Plants, Carbon Capture, Utilization, and Storage
- Combined Cycle
- Environmental Controls
- Major Component Reliability
- Materials and Chemistry
- Operations and Maintenance
- Power Plant Water Management
- Renewable Energy

Power Delivery and Utilization

Distribution and Energy Utilization

- Distribution
- Energy Utilization
- Information, Communication, and Cyber Security

Transmission

- Grid Operations and Planning
- Transmission and Substations

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Nuclear Sector Membership

U.S. PARTICIPANTS

All U.S. nuclear owners/operators

99 reactors

+

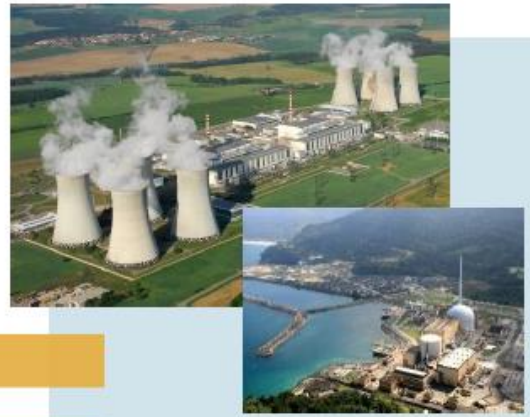
NON U.S. PARTICIPANTS

20 countries

>220 reactors

=

GLOBAL BREADTH & DEPTH



>75% of the world's commercial nuclear units

[Participants Encompass Most Nuclear Reactor Designs]

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

ANT Program Mission

The EPRI Advanced Nuclear Technology (ANT) Program leads Research and Development (R&D) through EPRI's collaborative model to proactively evaluate and address issues regarding the development and deployment of new nuclear plants.

The ANT Program is a scientific research program for those around the world and at various stages of new nuclear plant development and deployment, concentrating on the economic, technical, and regulatory issues that could affect the ability to license, construct, start-up, and operate new nuclear plants for energy production.

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ANT Technical Focus Areas

- **Engineering, Procurement, and Construction (EPC)**
  - Siting, design, construction materials, and construction activities of the physical plant, including modular construction
- **Materials and Components (M&C)**
  - Primarily class 1, 2, and 3 piping systems and related components such as valves, heat exchangers, and pumps
  - Optimize methods for fabricating, installing, joining, inspecting, and operating M&C (includes chemistry)
  - New applications of materials and components
- **Modern Technology Application (MTA)**
  - Maximize the use of existing, enabling, emerging, and non-nuclear specific, technology in new nuclear plants

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ANT publication process

- Nuclear sector publishes 300+/- per year
- ANT publishes approximately 20-30 per year
- Annual process to determine cost to public
- Decision to make free to public at time of publication
  - PM's role
  - PGM's role
  - Influence of publication

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Points of Clarification from NRC SDO Forum (2016)

1. The three technical focus areas, is this for nuclear or for ANT?
2. ACI 318 (and consequently, 349) interest in high-strength reinforcing steel.
3. The driver to influence ACI 301 relative to ACI 207 when dealing with mass concrete.
4. What is the status of alloy code development in Section II and Section III?
5. What is EPRI's interest in connecting with relevant IEEE committees on advanced batteries (commentator noted IEEE standards on Valve Regulated Lead Acid [VRLA])?

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Projects expected to have influence on standards

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List of Active Engineering, Procurement, and Construction (EPC) Projects (Applicable to SDO)

- **2009-07: Next Generation Attenuation Model for the Central and Eastern U.S.**
- **2012-06: High Strength Reinforced Rebar**
- 2012-15: New Steam Generator Thermal - Hydraulics Code (Triton)
- **2015-10: Mass Concrete Modeling & Temperature Control**
- 2015-11: Assessment of Moisture Tolerant Coatings for Decreasing Open Top Construction Time
- **2015-13: SMR Aerosol Project (Technology Innovation (TI), DOE, & ANT)**
- 2017-01: Optimization of Concrete Placement
- **2017-04: A Vertical Response Motion Computation in SSI Analysis of Embedded Structures**
- **2017-06: Ground Motion Kappa Parameter Assessment**
- 2017-09: Investigating Mechanical Splicing of Reinforcing Steel
- 2017-13: Nondestructive Evaluation for Steel-Concrete Members
- 2017-14: Engineering Programs Guide for New Nuclear Plants

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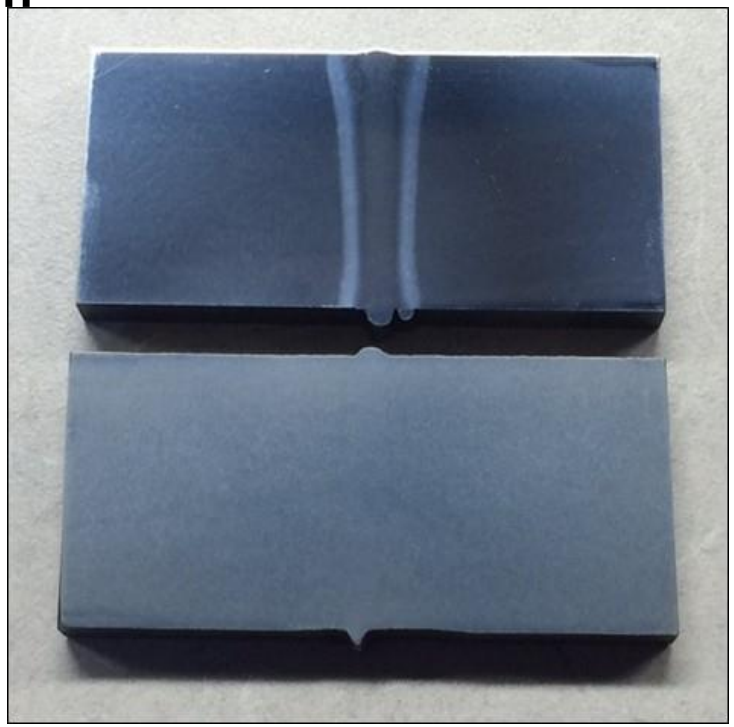
List of Active Materials and Components (M&C) Projects (Applicable to SDO)

- **2010-11: Methodology for Risk Informed Strategies**
- **2013-03: PWSCC Initiation Testing for Alloy 690 Weld Metals**
- **2013-07: Residual Stress (RS) Guidelines**
- **2015-03: Environmentally Assisted Fatigue – Long-Term Collaboration and Testing**
- 2015-05: Additive Manufacturing of Powder Metallurgy Cans for Valves
- **2015-06: Alloy Code Development for Powder Metallurgy Cans for Valves**
- 2016-02: PM-HIP Manufacturing Demo. of ALWR and SMR Components
- **2016-06: Advanced Manufacturing Program (TI)**
- **2016-08b: Qualification of Additive Manufacturing Components for Nuclear Applications**
- **2017-03: Investigation of New Residual Stress Mitigation Techniques**
- 2017-08: Comprehensive Identification of New Plant NDE Needs
- 2017-10: Guidance on the Application of HDPE Piping (with BOPC)
- 2017-11: Economic Evaluation of Upgrading Materials for New Plants



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List of Active Modern Technical Application (MTA) Projects (Applicable to SDO)

- 2016-01: Cyber Security During Construction
- 2016-03: Augmented Reality for New Plant Applications
- 2017-02: Assessment of Automation Technologies to Reduce Chemistry and Radiochemistry O&M Costs
- 2017-05: Risk Informed and Enhanced Cyber Security Vulnerability Assessment Methods for New Plants
- 2017-07: Alarm Prioritization and Filtering Methodology Improvement
- 2017-12: Evaluation of Indoor Positioning Systems

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Recently Completed Projects

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Recently Completed Projects – EPC

- **Bold Title** answers, "Does this have potential influence on SDOs?"
- **Y/N** answers, "Is document current free to the public?"

EPC RFA #1: Increase Efficiency and Reduce Cost of New Nuclear Construction
Advanced Nuclear Technology: Anchorage of High-Strength Reinforcing Bars with Standard Hooks (3002005440) Y
Advanced Nuclear Technology: Anchorage of High-Strength Headed Reinforcing Bars (3002007535) Y
Advanced Nuclear Technology: Demonstration and Evaluation of Self-Consolidating Concrete Mixtures (3002007567) N
EPC RFA #2: Development of Collaborative Engineering, Design Tools, and Processes
Advanced Nuclear Technology: Siting Guide: Site Selection and Evaluation Criteria for New Nuclear Power Generation Facilities (3002005435) **N**
Advanced Nuclear Technology: Advanced Light Water Reactor Utility Requirements Document, Revision 13 (3002003129) **N** / SMR Inclusion (3002003130) **Y**
Advanced Nuclear Technology: Central and Eastern United States Seismic Source Characterization for Nuclear Facilities (3002005288) Y
Advanced Nuclear Technology: Seasonal/Annual Cooling Tower Impacts (SACTI) Version 2.0 (3002006350) **Y**
Advanced Nuclear Technology: Emergency Planning Zone Size Evaluation for Small Modular Reactors (3002008037) N
Advanced Nuclear Technology: High-Frequency Seismic Loading Evaluation for Standard Nuclear Power Plants (3002009429) Y
Advanced Nuclear Technology: Assessment of Moisture-Tolerant Coatings for Decreasing Open Top Construction Time (3002010463) **N**
EPC RFA #3: Improve Quality of Supply Chain for Nuclear
Advanced Nuclear Technology: Supplier Quality Management for New Nuclear Plant Construction Projects (3002000521) **Y**

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Recently Completed Projects – M&C

- **Bold Title** answers, "Does this have potential influence on SDOs?"
- **Y/N** answers, "Is document current free to the public?"

M&C RFA #1: Advanced Fabrication and Manufacturing Techniques
Advanced Nuclear Technology: Innovative Manufacturing Process for NPP Components via PM-HIP: …Steam Separator Inlet Swirler (3002005403) N
Program on Technology Innovation: Innovative Manufacturing Process for NPP Components Through PM-HIP (3002008030) N
Advanced Nuclear Technology: Elimination of Dissimilar Metal Welds Using Powder Metallurgy–Hot Isostatic Pressing (3002008031) N
Advanced Nuclear Technology: Alloy Code Development for Powder Metallurgy-Hot Isostatic Pressing (3002010465) N
Advanced Nuclear Technology: Thick Section Component Welding (3002009557) N (3002005438) N
M&C RFA #2: Material Performance and Inspection
Advanced Nuclear Technology: Risk-Informed In-Service Inspection/Risk-Informed Break Exclusion Region Results for First Site (3002003119) N
Advanced Nuclear Technology: Generic ALWR Water Chemistry Guidelines (3002008028) **N** (3002008295) **N**
Advanced Nuclear Technology: Guidance for Advanced Light Water Reactor Primary System Component Residual Stress Management (3002005402) **N**
Advanced Nuclear Technology: Comparison of Residual Stress Modeling and Measurement of a Small Modular Reactor Nozzle (3002010464) **N**
Environmentally Assisted Fatigue Gap Analysis and Roadmap for Future Research: Roadmap (1026724) **Y**
Advanced Nuclear Technology: ASME Code Acceptance of HDPE (3002008761) Y (3002003120) Y (30020000524) N
Advanced Nuclear Technology: Development of Real Time Nondestructive Evaluation for Weld Inspections (3002010468) N
Nondestructive Evaluation: Guidelines for Inspectability of New Plant Components (1021160) **N**
Advanced Nuclear Technology: Major Component Replacement Sourcebook with Applicability to New Plant Water Chemistry (3002007516) **N**
Generic Evaluation of Environmentally Assisted Fatigue in BWR and PWR Reactors: A Feasibility Study (3002003922) **N**

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Recently Completed Projects – MTA

- **Bold Title** answers, "Does this have potential influence on SDOs?"
- Y/N answers, "Is document current free to the public?"

MTA RFA #1: Advanced Monitoring Technology and Data Management
Advanced Nuclear Technology: Embedded Sensors in Concrete (1023006) N
Advanced Nuclear Technology: Using Technology for SMR Staff Optimization Improved Effectiveness and Cost Containment (3002007071) Y
MTA RFA #2: Technologies to Improve Human Performance, Machine Interaction, and Operational Effect.
Advanced Nuclear Technology: Augmented Reality Technologies for New Nuclear Plant Applications (3002010467) N
Human Factors Guidance for Control Room and Digital Human-System Interface Design and Modification (3002004310) N
MTA RFA #3: Gaps for Use of Digital Systems Technologies in New Plants
Advanced Nuclear Technology: Guidance for Cyber Security During New Nuclear Plant Construction (3002010470) N
Advanced Nuclear Technology: Guidance and Methodologies for Managing Digital Instrumentation and Control Obsolescence (3002002852) N
Advanced Nuclear Technology: Requirements Engineering for Digital I&C Systems (3002002843) N
Advanced Nuclear Technology: Network Protocols Networking (TI) (3002008039) Y

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Proposed 2018 and 2019 Projects

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Proposed 2018 and 2019 Projects – EPC

Engineering, Procurement & Construction (EPC)	
EPC RFA #1: Increase Efficiency and Reduce Cost of New Nuclear Construction	
EPC 2018-B	Field Guide for Inspection of Reinforced Concrete Construction
EPC 2017-E (2018)	Demonstration of Self Consolidating Concrete Flow Simulation Software
EPC 2019-A	Report on Enhanced Concrete Formwork Technologies
EPC RFA #2: Development of Collaborative Engineering, Design Tools, and Processes	
EPC 2018-A	Overview of Alternative Concrete Reinforcement Materials and Methods
EPC 2018-C	Guide to Designing Structures for Constructability
EPC 2019-C	MAAP Benchmarking against iPWR Aerosol Data and Update for iPWRs
EPC 2019-D	Cost Basis for Utilizing Seismic Isolation for Design
EPC RFA #3: Improve Quality of Supply Chain for Nuclear	
EPC 2019-B	Guide to Evaluating and Developing Suppliers and Vendors

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Proposed 2018 and 2019 Projects – M&C

Materials & Components (M&C)	
M&C RFA #1: Advanced Fabrication and Manufacturing Techniques	
M&C 2018-E (2019)	Development of Adaptive Feedback Welding for Repair and Fabrication
M&C 2018-D (2019)	Evaluation of New Anti-Degradation Surface Treatment Technologies for New Plants
M&C RFA #2: Material Performance and Inspection	
MC 2018-C	NEI 03-08 Implementation Guidelines for Advanced Light Water Plants
MC 2018-B	PWSCC Testing and Revision to Alloy 690 Specification
MC 2018-G	Water Chemistry Control for SMRs
MC 2019-A	Risk Informed Strategies for SMRs
M&C RFA #3: New Materials Development	
MC 2018-F	New Material Scoping Assessment

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Proposed 2018 and 2019 Projects – MTA

Modern Technology Application (MTA)	
MTA RFA #1: Advanced Monitoring Technology and Data Management	
MTA 2017-E (2018)	Gaps and Opportunities for Sensor Applications
MTA 2018-A	Additional Water Chemistry Automated Technology Applications and Pilots
MTA 2018-C	Technical Evaluation of Using IPAWS and WEA Notification Systems
MTA 2018-D	Optimization of Radiation Monitoring and Protection
MTA RFA #2: Technologies to Improve Human Performance, Machine Interaction, and Operational Effect	
MTA 2019-B	Investigation of Virtual Technical Assistant
MTA 2018-B (2019)	Applications for Common Platform Robotic Systems
MTA 2019-A	Assessment of Advanced Security Technologies
MTA RFA #3: Gaps for Use of Digital Systems Technologies in New Plants	
MTA 2019-C	Updates to HFE Guidelines

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Advanced Reactor Strategic Program

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EPRI Advanced Reactor Strategic Program

- Vision: EPRI will play a leading role to enable commercialization of advanced nuclear generation on timeframes and at scales needed
  - Collaboration and leveraging for impacts commensurate with those of the Advanced Light Water Reactor (ALWR) program
  - Aligned with broader EPRI strategic vision: The Integrated Energy Network

- Objective: Build foundation for advanced nuclear technology now for options later (i.e., 2030 +)

- Program Focus:
  - Owner-operator Requirements Guide (ORG)
  - Early Integration of Risk and Safety Analysis
  - Economics
  - Advanced Materials

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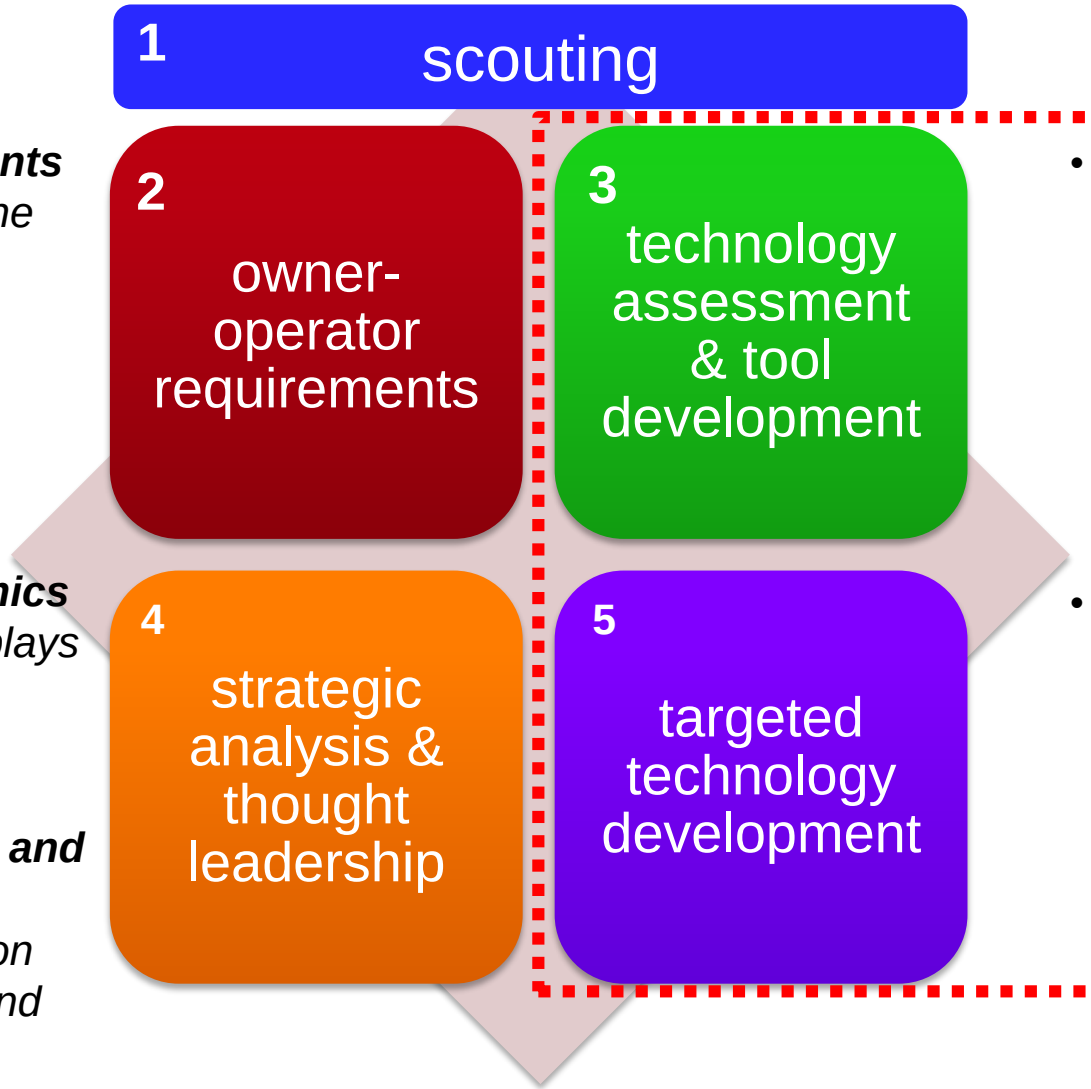
EPRI Advanced Reactor Strategic Program

- ***Owner-Operator Requirements Guide (ORG):*** *identify what the customer wants*

- ***Advanced Reactor Economics Study:*** *identify how nuclear plays in future energy markets*

- ***Public-Private Partnerships and Expanding Concept of Flexibility:*** *shape discourse on advanced nuclear valuation and commercialization*



- ***PHA 2 PRA Guide (P2PG):*** *enhance design-to-license process via integration of safety analysis*

- ***Advanced Materials and Fabrication for Advanced Reactors:*** *introduce new materials and fabrication methods*

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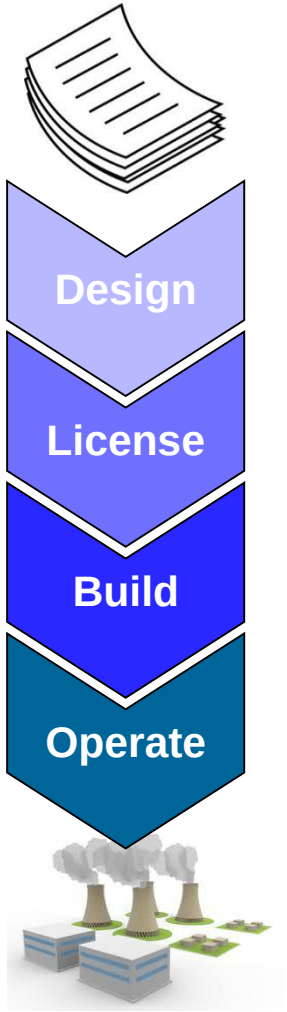
Early Integration of Safety Analysis in the Design Process

- Developers face considerable challenges building a safety case in a balanced, incremental manner to licensing and operation

- EPRI seeks to define an approach that facilitates the design-license-build-operate lifecycle through early integration of safety analysis through:
  - phased application of qualitative and quantitative methods, e.g., Process Hazard Analysis (PHA) and Probabilistic Risk Assessment (PRA)
  - collection of existing methods and best practices
  - demonstration via one or more pilots with advanced reactor developers

- Early integration of safety analysis can inform design process and prioritization: early design changes are easier and cheaper



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Project Participants + Context

VANDERBILT UNIVERSITY

PHA

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PRA

B. John Garrick Institute for the Risk Sciences

UCLA ENGINEERING

ASME/ANS RA S-1.4-2013

Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants

TRIAL USE AND PILOT APPLICATION

Publication of this Standard for trial use has been approved by ASME and ANS. Distribution of this Standard for trial use and comment shall not continue beyond 36 months from the date of publication, unless this period is extended by action of the JCNRM. It is expected that following this 36-month period, this draft Standard, revised as necessary, will be submitted to the American National Standards Institute for approval as an American National Standard. A public review in accordance with established ANSI procedures is required at the end of the trial use period and before a Standard for trial use may be submitted to ANSI for approval as an American National Standard. This trial use Standard is not an American National Standard.

Comments and suggestions for revision should be submitted to:

Secretary, Joint Committee on Nuclear Risk Management
The American Society of Mechanical Engineers
Two Park Avenue
New York, NY 10016-5990

The American Society of Mechanical Engineers

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

NUREG-1860
Vol. 1

Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing

Main Report

Office of Nuclear Regulatory Research

Industry-Led Licensing Modernization Initiative

ANSI/ANS-30.1-201x

American National Standard

Integrating Risk and Performance Objectives Into New Reactor Safety Designs

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GEN IV Materials Gap Analysis

- Materials Gap Analysis will lead to identification of new alloys needs/requirements, including Code options.

Topics Covered in Gap Analysis:

I. Materials Considerations/Requirements to be covered.

- Reactor materials
- Reactor internals materials
- Coolant piping, valve, and pump materials
- Secondary piping materials
- Steam generator, pressurizer

II. Materials Property/Environmental Considerations to be covered

- Creep & Creep-fatigue
- General corrosion, oxidation, SCC
- Irradiation damage
- Manufacturing Options (forging, PM-HIP, extrusion, other)
- Weldability, cladding, hardfacing
- Alloy cost

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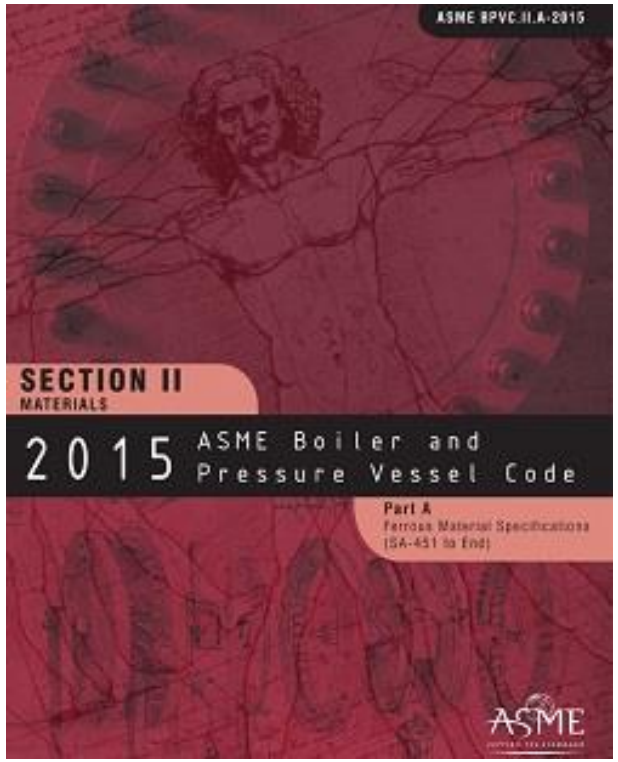
Complex Alloys/Components Manufacturing

- Powder Metallurgy-Hot Isostatic Pressing (PM-HIP) will be used to produce many GEN IV components.
- EPRI is working with ASME BPV-II to incorporate 3 ASTM specs: A988 (austenitics), A989 (ferritics) and B834 (nickel-based) directly into BPV-II.
- * If successful, ~30 alloys covered under these 3 specs could be produced by PM-HIP
- Also, revised Mandatory Appendix 5
  - Appendix 5 provides guidance for approval of "new materials" under ASME BPVC
  - Revision allows "HIP components" for approval similar to wrought or cast products from a qualification standpoint
  - * Approved by Standards Committee



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Together…Shaping the Future of Electricity

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BACKUP SLIDES

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Projects expected to have influence on standards

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EPC

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List of Active Engineering, Procurement, and Construction (EPC) Projects (Applicable to SDO)

- **2009-07: Next Generation Attenuation Model for the Central and Eastern U.S.**
- **2012-06: High Strength Reinforced Rebar**
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- **2015-10: Mass Concrete Modeling & Temperature Control**
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- **2015-13: SMR Aerosol Project (Technology Innovation (TI), DOE, & ANT)**
- 2017-01: Optimization of Concrete Placement
- **2017-04: A Vertical Response Motion Computation in SSI Analysis of Embedded Structures**
- **2017-06: Ground Motion Kappa Parameter Assessment**
- 2017-09: Investigating Mechanical Splicing of Reinforcing Steel
- 2017-13: Nondestructive Evaluation for Steel-Concrete Members
- 2017-14: Engineering Programs Guide for New Nuclear Plants

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2009-07: Next Generation Attenuation (NGA) Model for the Central and Eastern United States

Issue:

- Attenuation prediction equations are used to calculate seismic hazards for a given site
- There is a large level of uncertainty in the prediction of ground motions due to seismic event given a specific distance and magnitude of the dynamic action
- The increased certainties lead to conservative hazards levels for the sites
- Industry could use a more accurate probabilistic seismic hazard analysis

Scope:

- Perform a comprehensive review of ground motions within central and eastern United States
- This project will include building computer models utilizing more accurate seismological constraints
- Develop update equations for prediction of ground-motions
- Provide ample opportunity for technology transfer of findings of the model

SDO / CODE:

- **SDO/CODE:** NRC
- **Document:** 10CFR50
- **Status:** project has been delayed with completion scheduled for Dec fo 2017 at which time findings will be submitted to NRC
- **EPRI PM:** Ron King

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2012-06: High Strength Reinforced Rebar

Issue:

- Currently, reinforcing steel for concrete in nuclear related structures is limited to 40 and 60 ksi steel (and some limited uses of 80 ksi steel)
- Use of higher-strength steel has not been studied in a sufficient manner for ACI code committees to accept its widespread use
- Use of higher strength steel would reduce cost of material, labor, and congestion of steel

Scope:

- Evaluate reinforcing steel up to 120 ksi
- Concentrate testing on areas where steel congestion is the highest
- Include anchorage testing of hooked bars and headed bars and shear capabilities of headed bar reinforcement

SDO/ CODE:

- **SDO/CODE:** ACI
- **Document:** ACI 318 and 349
- **Status:** presented to ACI 318 to pursue potential revisions for the next code cycle
- **EPRI PM:** David B. Scott

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2015-10: Mass Concrete Modeling and Temperature Control

Issue:

- Construction specifications limiting early age temperature to 70˚ C (158˚ F) for delayed ettringite formation (DEF)
- Construction specifications limit temperature differential to 20˚ C (35˚ F)
- Previous research does not take into account supplementary cementitious material (SCM)

Scope:

- Utilize finite element modeling in concrete structures for prediction of internal strains/stresses and temperature limits
- Validate higher temps for mass concrete at early ages

SDO/ CODE:

- **SDO/CODE:** ACI
- **Document:** ACI 301
- **Status:** project to be completed in 2018
- **EPRI PM:** David B. Scott

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2015-13: iPWR Aerosol Project (TI, DOE, & ANT)

Issue:

- Reactor containment performance is a critical defense-in-depth barrier for the prevention of radioactive release in the event of a nuclear accident
- RG 1.183 allows the use of aerosol natural deposition correlations to quantify post-accident nuclear containment decontamination factors
- Studies suggest that the smaller containment vessel volume to surface area ratio would significantly enhance decontamination factors for these smaller designs.

Scope:

- Develop data to support use of decontamination factors based on natural phenomenon
- Develop correlation for large LWRs, iPWR-specific source terms
- Test using a SMR test loop with varying parameters (e.g.; temperature, pressure, containment value/surface area ratio, particle size, particle velocity, steam concentration)

SDO/ CODE:

- **SDO/CODE:** NRC
- **Document:** Regulatory Guide 1.183, *Alternate Radiological Source Terms for Evaluating Design Basis Accidents and Nuclear Power Plants*
- **Status:** project scheduled for completion at end of 2017
- **EPRI PM:** Ron King

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2017-04: A Vertical Response Motion Computation in SSI Analysis of Embedded Structures

Issue:

- Vertical input motion is calculated using V/H ratios applied to the calculated horizontal response spectrum at the foundation level in the soil column.
- As part of SSI analysis, the vertical free-field motion is amplified from foundation horizon to the ground surface.
- As a result, the vertical motion in SSI analysis is overestimated.

Scope:

- Using appropriate site dependent V/H ratios (the SSI methodology), computer programs can be modified so that the free-field motion in SSI analysis maintains the appropriate V/H ratio within the soil column.
- The approach will be tested for both the soil and rock sites using the modified SSI approach.
- Identify a path for implementation based on the results of the project.

SDO/ CODE:

- **SDO/CODE:** NRC
- **Document:** NUREG 0800
- **Status:** deliverable planned for 1Q 2018
- **EPRI PM:** David B. Scott

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2017-06: Ground Motion Kappa Parameter Assessment

Issue:

- Current seismic hazard estimates in the United States are showing considerable high frequency content, particularly at rock sites.
- Recent reviews of the “kappa” parameter suggest that the high frequency ground motion estimates are conservative.

Scope:

- Reassess the original EPRI studies from 1995 that first suggested the HF ground motions
- Review newer global data sets (Japan, Switzerland, and others)
- Estimate kappa for rock sites using the updated global ground motion data.
- Develop updated empirical model and high frequency scaling factors for rock sites.

SDO/ CODE:

- **SDO/CODE:** NRC
- **Document:** NUREG 0800
- **Status:** gathering US and international ground motion data
- **EPRI PM:** John Richards and David B. Scott

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M&C

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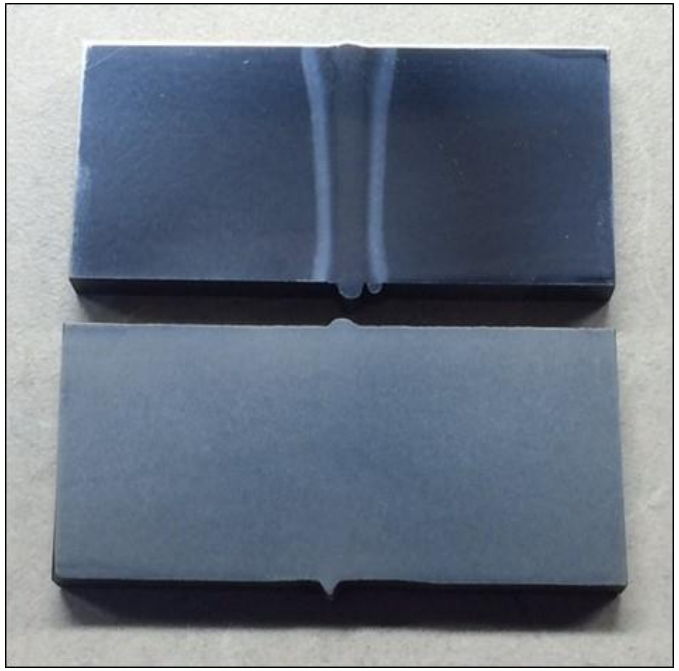
- 2015-05: Additive Manufacturing of Powder Metallurgy Cans for Valves
- **2015-06: Alloy Code Development for Powder Metallurgy Cans for Valves (ASTM and ASME)**
- 2016-02: PM-HIP Manufacturing Demonstration of ALWR and SMR Components
- **2016-06: Advanced Manufacturing Program (TI)**
- **2016-08b: Qualification of Additive Manufacturing Components for Nuclear Applications (ASME Section III)**
- **2017-03: Investigation of New Residual Stress Mitigation Techniques (ASME Sections III, IX, and XI)**
- 2017-08: Comprehensive Identification of New Plant NDE Needs
- 2017-10: Guidance on the Application of HDPE Piping (with BOPC)
- 2017-11: Economic Evaluation of Upgrading Materials for New Plants



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2010-11: Methodology for Risk Informed Strategies

Issue:

- Risk informed (RI) strategies are currently being used for nuclear new-builds.
- Utilities use these practices during various phases of the licensing process for the sites (e.g.; design certification, early site permit, and combined construction and operation license application)
- Updated and improved risk-informed strategies can be used to file relief requests

Scope:

- Project is a multiyear, multi phased project
- Tasks include developing methods for RI procurement, test cases for RI procurement, pilot submittal requests, updates to RI based on site feedback to RI procurement process

SDO/ CODE:

- **SDO/CODE:** ASME and NRC
- **Document:** PRA Standard; 10CFR50.69
- **Status:** ASME balloting for updated PRA Standard expected in 2016. A petition for rule change in 10CFR50.69 has been issued to address language interpretations.
- **EPRI PM:** Craig Stover

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2013-03: PWSCC Initiation Testing for Alloy 690 Weld Metals

Issue:

- Inspection intervals for SCC are based on assumption that cracks exist on day 1 and crack growth until safety critical.
- However, crack initiation and expansion to detectable levels represent ~80% of component life.
- Additional time date for crack initiation and propagation is needed.

Scope:

- Develop SCC time data for crack initiation and growth
- Testing will be focused on Alloy 690 welds (A52 and A152 weld metals)
- Perform literature review and determine if technical justification for expanding inspection interval times

SDO/ CODE:

- **SDO/CODE:** ASME
- **Document:** dependent upon weld location (see subsequent slide with table)
- **Status:** code case revisions to support decreased inspection frequencies
- **EPRI PM:** Eric Harvey

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Area	ASME	Regulation
Upper Head	ASME CC N-729-1	10 CFR 50.55a(g)(6)(ii)(D)
Pressurizer	ASME CC N-722-1	10 CFR 50.55a(g)(6)(ii)(E)
Lower Head	ASME CC N-722-1	10 CFR 50.55a(g)(6)(ii)(E)
DM Welds	ASME CC N-770-1	10 CFR 50.55a(g)(6)(ii)(F)

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2013-07: Residual Stress (RS) Guidelines

Issue:

- Residual Stress is a key component of SCC which is plaguing LWRs
- Poor performance and failures NRC shutdown orders; costly repair, replace, inspection and mitigation aging management solutions; owner/regulator uncertainty in managing stress levels; over $10 billion dollars spent on SCC
- Optimized performance is required from initial start-up through 80-year life.

Scope:

- Phase 1: Guideline definition, generic surveys, workshops, feasibility, assessments, scoping and gap identification, and detailed R&D plan
- Phase 2: Modeling and validation of processes that contribute to component RSs
- Phase 3: Prepare a guideline on management of RS in advance nuclear plants

SDO/ CODE:

- **SDO/CODE:** ASME
- **Document:** ASME, Section III
- **Status:** some publications have completed; evaluating select RSM techniques
- **EPRI PM:** Craig Stover

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2015-03: Environmentally Assisted Fatigue – Long-Term Collaboration and Testing

Issue:

- NRC-approved methodologies result in typically conservative fatigue estimates and component usage factors
- ASME Code process: difficulty obtaining consensus and revision
- Lab data and plant experience discrepancy = differing technical positions

Scope:

- Systematic approach addressing gaps from prior EPRI research
- Evaluate existing analytical rules and develop test data that is representative of real-plant experience
- New plants application of RG 1.207 in concert with NRC involvement

SDO/ CODE:

- **SDO/CODE:** ASME and NRC
- **Document:** ASME Section III; NUREG 6720; NUREG/CR-6909; RG 1.207
- **Status:** RG 1.207 on periodic review basis at NRC
- **EPRI PM:** Craig Stover

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2015-06: Alloy Code Development for Power Metallurgy-Hot-Isotopic Powder

Issue:

- PM-HIP advancements has led to production of large, homogeneous components used for other, non-nuclear industries
- Nuclear power can benefit from these advancements but lacks the standard and code support for use by the industry

Scope:

- Identify material candidates with high-potential success for use in ALWR and SMR components
- Specific materials of interest include: SA508; A988; A989; N-834; alloys 600, 690, and 718; and 304L SS
- Develop data packages to support review and approval by standards and codes

SDO/ CODE:

- **SDO/CODE:** ASTM and ASME
- **Document:** ASTM B834, A988, A989, B834; ASME BPV-II (Section 2 and Appendix 5)
- **Status:** completed submissions to ASTM (B834) and ASME (BPV-II) for alloy 600, 625, and 690; work begun to incorporated PM-HIP to Section II and Appendix 5 (BPV-II); work on A988, A989, and B834 has now also been extended to SA508
- **EPRI PM:** Craig Stover and Dave Gandy

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2016-06: Advanced Manufacturing Program (Technology Innovation)

Issue:

- Many of today's manufacturing methods remain unchanged or have shown limited progress resulting in manufacturing methods that are antiquated, expensive, and slow.
- There are a number of innovative and cutting edge technologies that can fundamentally transform and revolutionize the fabrication and manufacture of new nuclear plants that need to be developed for nuclear implementation.

Scope:

- This strategic program will advance a number of innovative manufacturing technologies while assessing their feasibility for specific nuclear applications.
- Examples include; PM-HIP (powder metallurgy – hot isostatic processing), electron beam welding (EBW), and laser diode cladding.

SDO/ CODE:

- **SDO/CODE:** ASME
- **Document:** ASME Section II, III, and IX
- **Status:** plan to develop code changes around dissimilar metal welds, electron beam welding, and in-service inspection
- **EPRI PM:** Craig Stover and Dave Gandy

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2016-08b: Qualification of Additive Manufacturing Components for Nuclear Applications

Issue:

- There is potential to deploy Additive Manufacturing (AM) methods to produce reactor internal components with complex geometries rapidly with improved performance, while reducing the cost and time to market.
- However, code and regulatory bodies are skeptical about adopting these components for real-life service due to the scatter in metallurgical and mechanical properties emanating from machine specific process variations.

Scope:

- Develop an innovative qualification strategy for complex nuclear components produced by laser powder bed AM.
- Leverage relevant technology from recent welding developments, as well as, emerging process analytics, high- performance computation models, in-situ monitoring and big-data mining.

SDO/ CODE:

- **SDO/CODE:** ASME
- **Document:** ASME Section III
- **Status:** fabrication of first component is complete, more components are in-progress, report expected in December 2019
- **EPRI PM:** Craig Stover and Dave Gandy

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2017-03: Investigation of New Residual Stress Mitigation Techniques

Issue:

- Many alternative Residual Stress Mitigation techniques are available in industry that have not been investigated for nuclear application

Scope:

- Identify RSM techniques for evaluation
- Identify key locations (thicknesses or geometries) that are good candidates for new RSM techniques. What are applications that current techniques do not address?
- Select RSM techniques for further evaluation
- Develop a qualification plan
- Conduct testing of RSM methods

SDO/ CODE:

- **SDO/CODE:** ASME
- **Document:** ASME Section III, IX, and XI
- **Status:** identifying key locations and candidate mitigation techniques are in-progress, echnical report scheduled for 2019
- **EPRI PM:** Eric Harvey

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MTA

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List of Active Modern Technical Application (MTA) Projects (Applicable to SDO)

- 2016-01: Cyber Security During Construction
- 2016-03: Augmented Reality for New Plant Applications
- 2017-02: Assessment of Automation Technologies to Reduce Chemistry and Radiochemistry O&M Costs
- 2017-05: Risk Informed and Enhanced Cyber Security Vulnerability Assessment Methods for New Plants
- 2017-07: Alarm Prioritization and Filtering Methodology Improvement
- 2017-12: Evaluation of Indoor Positioning Systems

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