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

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Update on DOE Consensus-Based Standards Efforts

Tom Sowinski
Office of Nuclear Energy
U.S. Department of Energy

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Motivation for DOE Standards Support

Codes and standards valuable to both industry and regulator

- Provide criteria, requirements, and/or methods that represent industry best practices
  - Reduces technical risk for industry
- Can be applied to satisfy regulatory requirements
  - Reduces regulatory uncertainty for industry
  - Guides review processes and enhances review efficiency for regulator

DOE supports industry codes & standards development through:

- Focused research providing the technical bases for new or modified codes & standards
- Codes & standards committee participation by subject matter experts

Advanced Reactor Materials

Advanced Non-Light Water Reactors (LWRs) include range of High Temperature Reactor (HTR) Technologies:

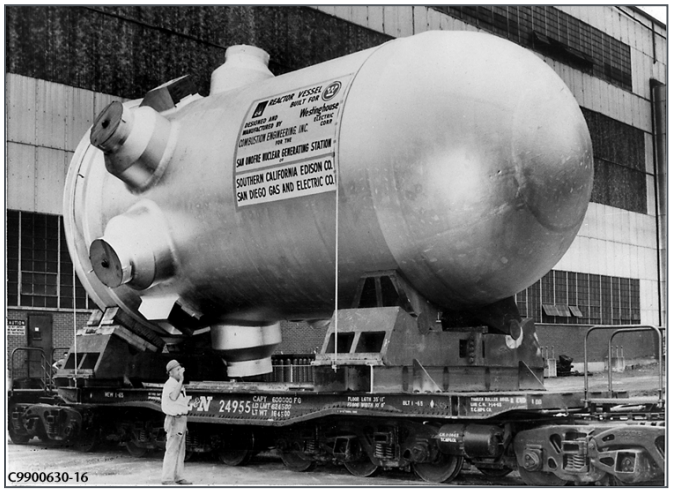
- High Temperature Gas-cooled Reactors (HTGRs)
- Liquid Metal-cooled Fast Reactors (FRs)
- Molten Salt Reactors (MSRs)

Each reactor technology has both unique and cross-cutting high temperature materials qualification needs

- HTRs have different coolants, neutron flux spectra, and operating conditions requiring different structural materials needs
  - Drives technology specific materials R&D
- High Temperature Material ASME Code development provides material qualification standards applicable to multiple HTR technologies
  - Drives ASME Section III Div. 5 Endorsement Efforts

ASME Sec. III Treats Metallic Materials Differently for High and Low Temperatures

- **For LWR & low-temperature advanced reactor components, allowable stresses not time dependent**
  - < 700° F (371 C) for ferritic steel
  - < 800° F (427 C) for austenitic materials



PWR RPV

- **At high temperatures, materials behave inelastically and allowable stresses are explicit functions of time & temperature**
  - Must consider time-dependent phenomena such as creep, creep-fatigue, relaxation, etc.
  - ASME Sec III Division 5 provides rules for construction of high temperature reactor components

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ASME Section III Division 5: High Temperature Reactors

Sec III Div. 5 contains construction and design rules for HTRs

- First Issued in Nov 2011
  - Revised in 2013, 2015 & 2017
- Covers high-temperature metallic components explicitly
- Includes rules for graphite & ceramic composites for core supports & internals
  - First time in any international design code
- Covers low temperature metallic components
  - Largely by reference to other portions of Sec III

ASME Sec III Div. 5 Requires Updates and Endorsement

Use of consensus-based codes and standards in advanced reactor regulatory framework can minimize time to completion, provide flexibility in implementation, and enhance regulatory surety

- Lack of NRC endorsement of ASME construction rules for advanced non-LWRs represents significant regulatory risk
  - Can delay development & deployment, increase system design & construction costs, and discourage commercial interest
- Discussions between NRC's Office of New Reactors, DOE-NE's Office of Advanced Reactor Technologies, and ASME's Sub-Group on High Temperature Reactors have initiated the process for NRC to evaluate and eventually endorse Division 5
  - NRC identified a need for industry input and ASME recommendation prior to initiating the endorsement process

ASME Task Groups Support Section III Division 5 Endorsement

Following multiple DOE-NRC Non-LWR Advanced Reactor Workshops and ASME meetings since 2015, ASME Task Groups have been formed to define potential pathways and schedules for NRC endorsement of Div 5

- DOE-NE supports ASME task groups & related technical basis development to reduce technical risk and support private sector deployment of new advanced reactors
  - Task Group On ASME/NRC Liaison For Division 5 - Metallic Components
  - Task Group On ASME/NRC Liaison For Division 5 – Nonmetallic Components
- NRC/NRO is actively participating in task groups
- ASME Section III and Board on Nuclear Codes and Standards (BNCS) have been highly supportive of Div 5 endorsement

Industry Support for Sec III Div 5 Endorsement

Significant progress has been made to gain nuclear industry support for the endorsement of ASME Section III, Division 5 by NRC

- Industry Technology Working Groups (TWGs) and vendors focused on HTGRs, FRs & MSRs provided input on value of endorsement of Div 5 for design of advanced reactors and reduction of anticipated risk for licensing and deployment
  - ASME received letters of support for Div 5 endorsement from HTGR TWG, FR TWG, TerraPower, and Elysium, with copies to NRC and DOE
- ASME BNCS subsequently developed a Div 5 endorsement recommendation letter based on TWG and industry input
  - **In June 2018, ASME formally recommended endorsement to NRC**
  - **NRC has now initiated the endorsement review process (June 2018)**
- ASME/NRC Task Groups continue to support endorsement effort

Update on ASME/NRC Task Group Efforts and Plans

Metallic Task Group

- White paper, "Technical Basis of Current Rules for Construction of Elevated Temperature Metallic Components in Section III, Division 5, of the ASME Boiler and Pressure Vessel Code," submitted to ASME, May 2018
- Develop white paper to assess the issue lists identified previously by NRC and ACRS *
  - The identified issues are for information and are not requirements
  - Will assess how the issues are addressed by the Division 5 rules and identify gaps, if any
  - Target completion: October 2018
- Develop Roadmap on ASME actions and schedule to address identified gaps (Target completion: February 2019)

Nonmetallic Task Group

- Develop Roadmap on ASME actions and schedule to address identified gaps (Target completion: February 2019)
  - The NGNP high temperature materials white paper issued in 2009 and information on subsequent interactions with NRC on RAIs will be used as the basis for developing the Roadmap

* O'Donnell, Hull and Malik, "Structural Integrity Code and Regulatory Issues in the Design of High Temperature Reactors," Proceedings of the 4th International Topical Meeting on High Temperature Reactor Technology, HTR-2008, Paper HTR2008-58061, American Society of Mechanical Engineers, New York, NY (2008)

DOE's ART Program Providing Technical Basis for ASME Div. 5 Additions

Additional materials being added to Division 5

- Alloy 617, high-temperature nickel-based alloy to allow higher temperature heat exchangers and steam generators
- Alloy 709, super stainless steel, to significantly improve high temperature strength and expand design envelop, performance, safety, and economics for advanced reactors
- Supporting development of advanced alloys compatible with molten salt reactors (both solid and liquid fuel) for code qualification

Additional high temperature design methods being added to Div 5

- Improved design rules at very high temperatures based on idealized elastic perfectly plastic (E-PP) material behavior
- Rules for use of compact heat exchangers for improved power conversion efficiencies and reduced plant footprint
- Rules for high-temperature cladded structures (proposed) for use of currently qualified ASME Div 5 materials and compatibility with molten salt reactors

Summary of DOE Advanced Materials Codes and Standards Efforts and Path Forward

DOE-NE has actively supported and coordinated industry and ASME R&D activities to optimize and endorse Div 5

- Endorsement of Div 5 is anticipated to reduce technical risk and support private sector deployment of new advanced reactors
- Requests for input on Div 5 endorsement from broad range of advanced reactor vendors and suppliers evoked positive responses
- ASME has formally recommended endorsement to NRC
- DOE's ART Program continues to perform R&D to support addition of new materials and enhanced methodologies to Div 5

DOE will continue to interact with key stakeholders to identify and address high priority codes and standards issues

- These priorities are a key input to the establishment and ongoing implementation of DOE's research and technical support activities

Update on DOE's Instrumentation and Control (I&C) Cybersecurity Standards Support

DOE-NE I&C Cybersecurity Program

Program Objectives:

- Perform R&D to help inform standards
  - Supports US industry I&C cybersecurity research
- Participate in international standards collaborations
  - Most international standards work supported by countries with advanced capability in cyber
  - Participation allows US to leverage lessons learned from international standards bodies with significant experience in implementing digital technology into nuclear systems

Work supported by both SNL and INL

- Efforts underway on cyber risk research, secure architecture development, and modeling and simulation
- Expect continued support of International Atomic Energy Agency (IAEA), International Electrotechnical Commission (IEC), Institute of Electrical and Electronics Engineers (IEEE), and American Nuclear Society (ANS) standards work
  - SNL supporting majority of international efforts

IAEA Standards Support

NP-T-X.XX: *Design Aspects of Computer Security for Instrumentation and Control Systems at Nuclear Power Plants (**DOE-supported Chair**)*

- A technical report offered as part of the Nuclear Energy Series
- Provides technical guidance to control system architects on how to secure digital I&C systems in nuclear power plants

NP-T-X.XX: *Approaches for Overall Instrumentation and Control Architectures of Nuclear Power Plants (**DOE-supported Member**)*

- Report (part of the Nuclear Energy Series) covering architectural issues in large control systems, including designing secure systems

IEC Standards Support

IEC 62859: *Instrumentation and control systems - Requirements for coordinating safety and cybersecurity (**DOE-supported Member**)*

- Standard provides framework to manage the interactions between safety and cybersecurity for nuclear power plant (NPP) systems
- Takes into account current IEC standards addressing these issues and the specifics of nuclear I&C programmable digital systems

IEC 63096: Instrumentation, Control, and Electrical Systems – Security Controls *(**DOE-supported Member**)*

- For I&C systems in nuclear power plants
- Standard specifically focuses on the selection and application of computer security controls from the included security controls catalogue, in order to prevent, detect and react to digital attacks against computer-based I&C systems.

IEEE NPEC Standards Support

P1891: Standard Criteria for Application of Intelligent Digital Devices to Nuclear Power Generating Stations *(**DOE-supported Vice Chair, SC6**)*

- Standard provides criteria and guidance for the use of intelligent digital devices/components in nuclear generating station applications
- Addresses a variety of topics including component and system cybersecurity

ANS Support

ANS is developing a standard, ANS-3.15, *Cyber-Physical Resilience for Nuclear Power Systems*

- Currently supporting ORNL subject matter expert to chair this effort
- SNL subject matter expert asked to be the deputy chair
- Standard has a broad DOE and US interest and NRC has assigned a staff member to support the work.

Thank you for your attention!

Questions?

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