

# Making ASME Codes and Standards Smaller

*“Small Modular Reactors and future  
ASME Codes”*

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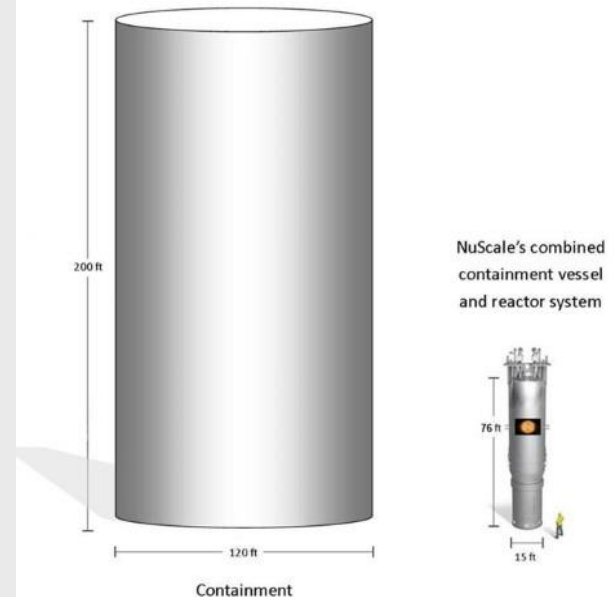
# Small Modular Reactors (SMR)

➤ SMRs are characterized by three main attributes:

- SMRs produce 300 megawatts (MWe) or less,
- Physically small enough to be manufactured in a shop environment,
- Incorporate advanced passive safety features.



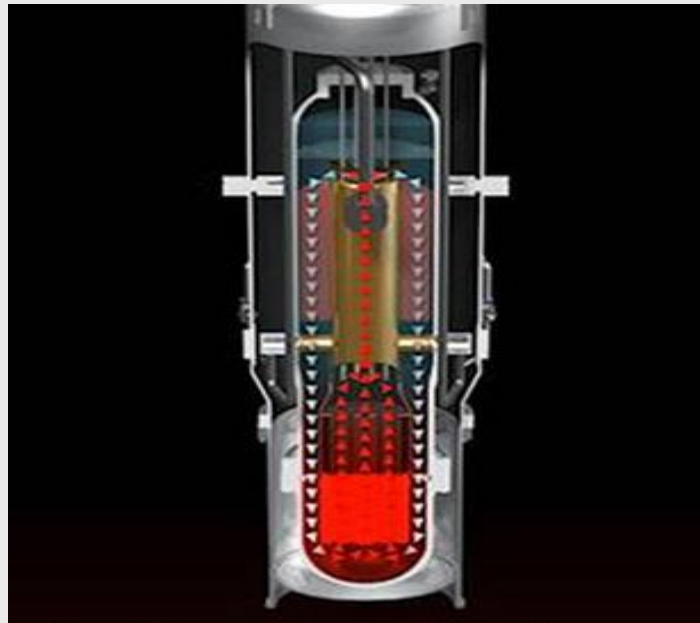
Comparison size envelope of new nuclear plants currently under construction in the United States



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# Small Modular Reactors (SMR)

- SMR designs currently in development are individually unique unto themselves.
  - Some SMR designs employ light water reactor (LWR) technology but have multiple integrated functions. (e.g., reactor and core, pressurizer, steam generator) in a single pressure vessel.



NuScale Reactor Design

# Small Modular Reactors (SMR)

- Some designs employ individual pressure vessel components for the reactor system.

Holtec's SMR-160 (HI-SMUR) Inherently-Safe Modular Underground Reactor



# Small Modular Reactors (SMR)

- Other categories of SMR currently in development also employ non-light water cooled reactor designs.
  - High Temperature Reactors (HTR) - gas cooled
  - Liquid Metal Reactors (LMR) - liquid metal cooled
  - Molten Salt Reactors (MSR) - salt cooled
  
- An all inclusive list of various SMR designs would be large, but the market suggests there are a dozen or so potential contenders and different designs.
  
- Initial deployment is expected within the next one to two decades.

# Small Modular Reactors (SMR)

- Advantages for SMR safety is they generally all employ simplified designs with enhanced and varied passive emergency systems.
  - Passive emergency cooling systems
  - Gravity fed emergency cooling systems
  
- This contrasts current plants that require “active” safety components such as:
  - Pumps for emergency core cooling
  - Back up or offsite power to provide power to run emergency cooling system pumps

# Small Modular Reactors (SMR)

- Many SMR designs do not need emergency diesel generators or offsite power to run their emergency core cooling functions.
  - Some SMR design features employ natural re-circulation
  - Reactor coolant media intrinsically provides for safe shut down and cooling the reactor (e.g., molten salt)
  - Submerged in pools that serve as emergency cooling systems
  - Underground reactor installations
- These integrated safety features make SMR less vulnerable to accident conditions.
  - Natural disasters
  - Terrorist threat
  - Increase the overall safety performance

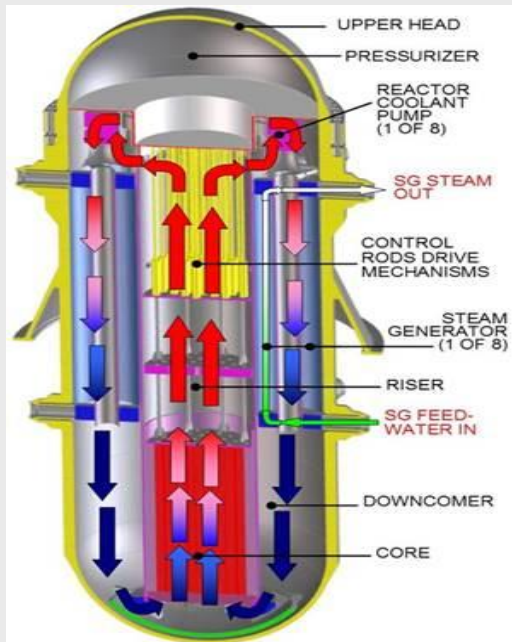
# ASME Nuclear Codes

- SMR designs often use either integrated function single pressure vessel or multiple pressure vessels.
- Use of ASME Section III lends itself well to accommodate pressure vessels needed for SMR new construction.
  - Some SMR designs may need to utilize ASME Section III Subsection NH “*Class 1 Components in Elevated Temperature Service*” rules, because a particular SMR design operates in a higher temperature regime than what would otherwise be permitted by ASME Section III Subsection NB “*Class 1 Components - Rules for Construction of Nuclear Facility Components*”.
- Therefore existing ASME Section III construction rules are already well postured to accommodate SMR and advanced reactor construction.



# ASME Nuclear Codes

- Some SMR designs use integrated function within a single pressure vessel.
- Even those SMR with separate pressure vessel components are generally small in dimension.
- This makes using traditional ISI approaches difficult.



Early SMR concept, the IRIS, demonstrates a single reactor with multiple functions.

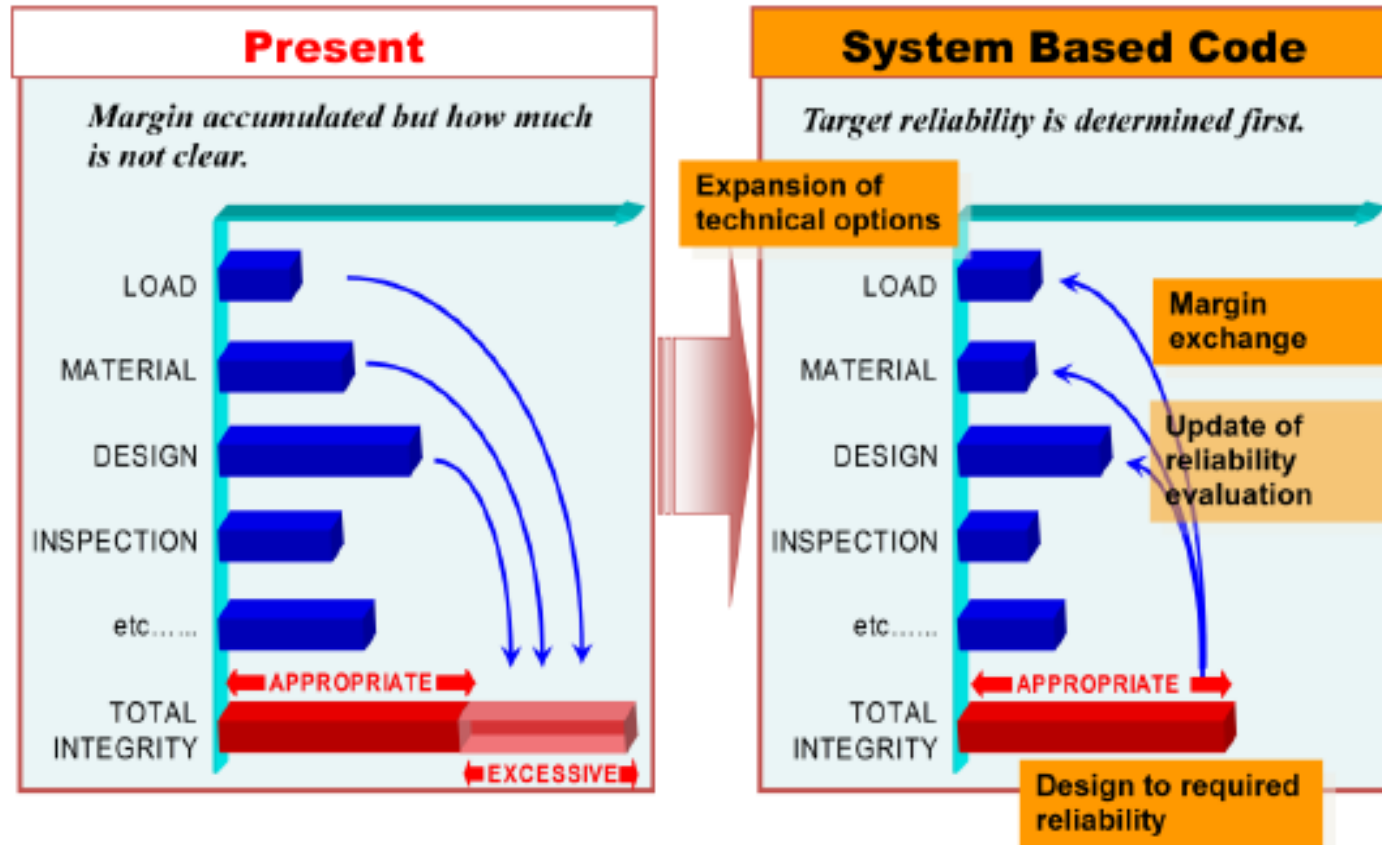
# ASME Nuclear Codes

- ASME Section XI Division 1 was developed and evolved over 30+ years but **focused** on existing PWR and BWR technology.
  - Consequently, the use of current ASME Section XI Division 1 is not well suited as an Inservice Code for many SMR and advanced design reactors.
- ASME Code Section XI Standards Committee is developing ASME Code Section XI, Division 2, entitled ***Reliability and Integrity Management*** (RIM) to address these advanced reactors.
- ASME Code Section XI, Division 2, will be a "technology neutral" inservice code that can be applied to all advanced reactor designs, including SMRs.
  - Division 2 will include technology-specific appendices intended to account for different reactor designs for Inservice Inspection (ISI) parameters.

# ASME Nuclear Codes

- ASME Code Section XI, Division 2 is built on a System Based Code (SBC) technical approach.
- This approach is used because it evaluates:
  - All systems and components for their relative consequences for maintaining overall plant safety and,
  - Establishes appropriate individualized monitoring parameters to assure long term reliability of critical SSC.
- This is opposed to the prescriptive approach used by Division 1 which uses the Class 1 (e.g., reactor coolant system), Class 2 (emergency core cooling systems) and 3 (e.g., tertiary systems) approach to ISI with each Class having less rigorous criteria for ongoing monitoring.

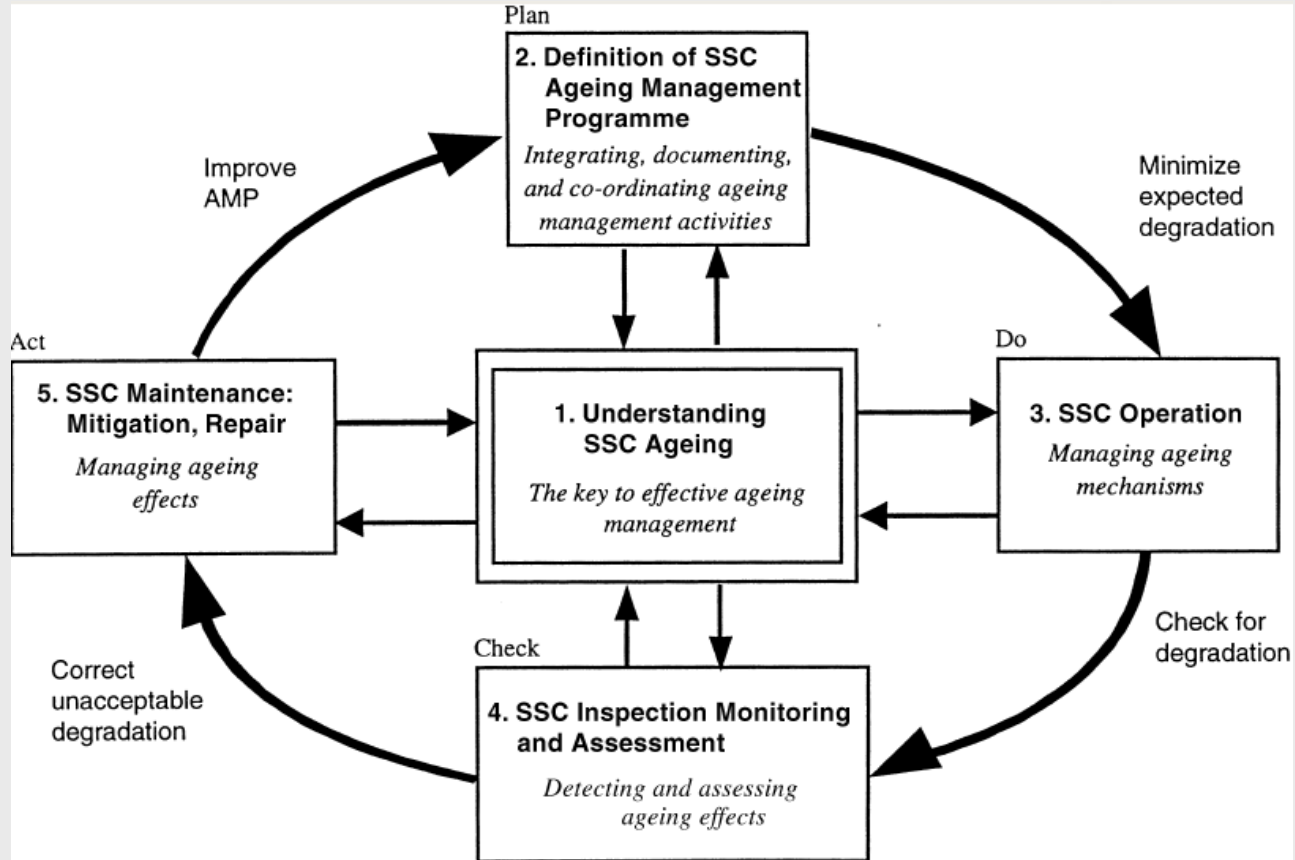
## ASME Nuclear Codes



# ASME Nuclear Codes

- A simplified description of the process employed by SBCs employed by ASME Code Section XI, Division 2 (RIM) follows:
  - Determine scope of Systems Structures and Components (SSC) for a specific reactor design to be included in the RIM Program
  - Evaluate SSC damage mechanisms
  - Determine plant and SSC level reliability requirements
  - Evaluate RIM strategies (ISI and monitoring needed) to assure reliability targets are met
  - Evaluate for any uncertainties in SSC reliability performance
  - Determine scope and parameters the specific SSC in the RIM Program
  - Continuously monitor SSC reliability performance over their operating cycle and continuously update the RIM Program over the life of reactor facility
- The RIM process also serves as a long term ISI aging management approach for SSC since it is a “living program”.

# ASME Nuclear Codes



# Authorized Inspection Agency Roles

- Under current ASME Code Section XI, Division 1 rules, ISI examinations are prescriptively required to be performed at discrete time periods during a typical 10-year inservice inspection interval.
  - Some advanced reactor designs may be designed for longer fuel cycles than today's typical PWR or BWR 18-to-24-month fuel cycle.
  - Typical 10-year ISI program interval would not serve for these advanced reactor designs.
  - *Real time* online monitoring of an SSC may provide for greater reliability and assurance of safe operations vs. traditional NDE methods used today.
- Therefore shifts in an Authorized Nuclear Inservice Inspector's (ANII) roles for ISI related activities for SMR and advanced reactor designs will be necessary.

# Authorized Inspection Agency Roles

- Traditional ISI examination NDE methods such as ultrasonic testing (UT), liquid penetrant (LP) testing, etc., may need to be replaced with more appropriate real time monitoring and surveillance techniques better suited for SMRs.
  - Online acoustic emission monitoring.
  - Periodic surveillance specimen testing (e.g., evaluate the onset of creep damage that may be applicable to some designs).
  - Active leakage measurement systems.



# Authorized Inspection Agency Roles

- Authorized Nuclear Inservice Inspectors (ANII) carrying out inspection functions with the RIM process will vary on the specifics of the RIM program developed for each unique SMR reactor design.
  - Necessitate that ANII become familiar with the plant-specific design and review the plant-specific RIM program documents
  - RIM programs for one design not appropriate to a different reactor design
- Essential that all of the established inspection methods, surveillance, or monitoring criteria applicable to a specific SSC are completed in accordance with the RIM program criteria relevant to that particular design.

# Summary

- Advanced nuclear reactors including SMRs have varied designs.
  - Shifts in the performance and approaches to ISI activities needed.
  - Changes will affect plant owners and authorized inspection agency personnel ISI activities.
- ASME Codes being developed to accommodate small modular reactors and new reactor designs.
- ASME XI Division 2's (RIM) approach will address SMR's and make ISI activities appropriate and **scalable** to these unique designs many which have smaller systems, structures and components.
- Improved safety features in SMR designs still need to be effectively monitored for long term safety assurance.
- The future of nuclear power like many other technological advances is moving toward miniaturization, but reactor safety and long term reliability remains paramount.

# Q & A Session

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