NuScale Power, LLC

Containment Functional Requirements
Nonproprietary

Containment Functional Requirements

Bill Galyean

July 18, 2012

NuScale Power™

Agenda

- Purpose
- Background
- Regulatory and related guidance
- Plant overview
- Containment vessel functional requirements
- Questions and next steps

Purpose

- Provide an understanding of containment functional requirements
- Discuss NuScale features that address functional requirements
- Provide background for severe accident discussion

Background

- Recap October 2011 meeting with NRC regarding containment
- Issues identified in the October 2011 meeting being worked on
  - NuScale no longer pursuing an ASME code case for containment wall material

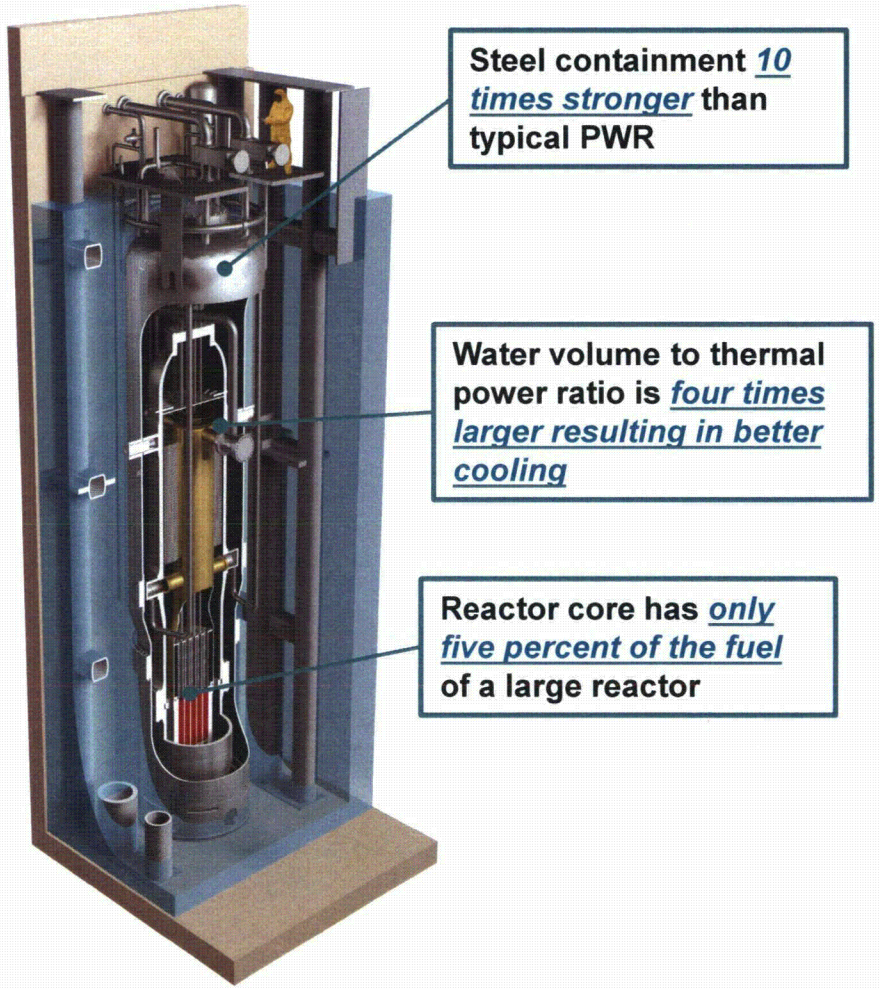
Regulatory and Related Guidance

- 10 CFR 50 Appendix A, "General Design Criteria"
  - Evaluating applicability to NuScale
- 10 CFR 50.44
  - Combustible gas control
- 10 CFR 50.60
  - Fracture toughness for reactor vessels
- ASME code Subsection NB (class 1 vessel)
  - CNV expected to be stamped as MC vessel
- Design-Specific Review Standard
  - SECY-11-0024

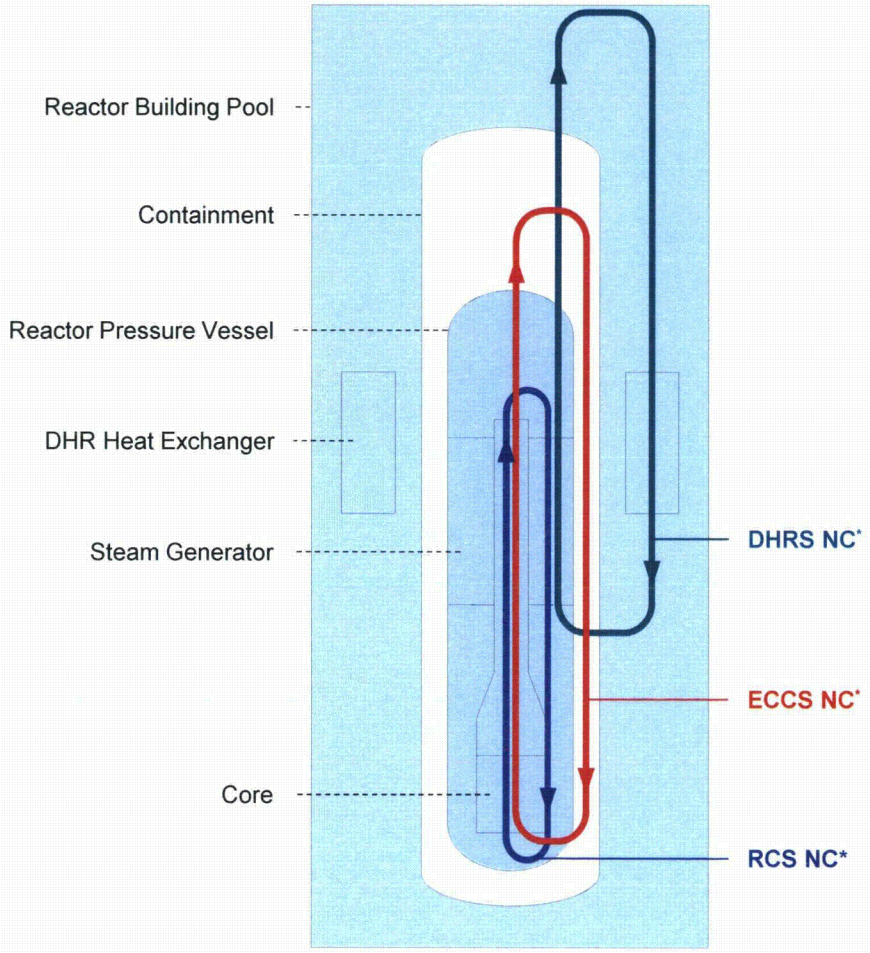
Plant Overview

- Natural Convection for Cooling
  - Passively safe, driven by gravity, natural circulation of water over the fuel
  - No pumps, no need for emergency generators
- Seismically Robust
  - System submerged in a below-ground pool of water in an earthquake resistant building
  - Reactor pool attenuates ground motion and dissipates energy
- Simple and Small
  - Reactor is 1/20th the size of large reactors
  - Integrated reactor design, no large-break loss-of-coolant accidents
- Defense-in-Depth
  - Multiple additional barriers to protect against the release of radiation to the environment

45 MWe Reactor Module



Plant Overview – Natural Circulation

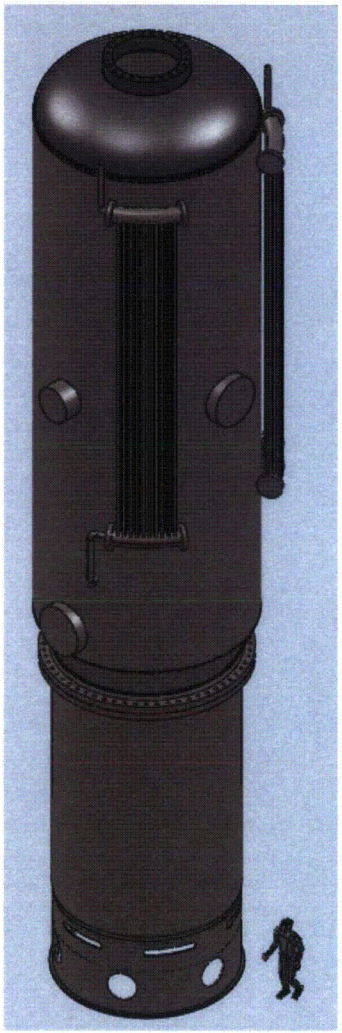


* NC: Natural Circulation

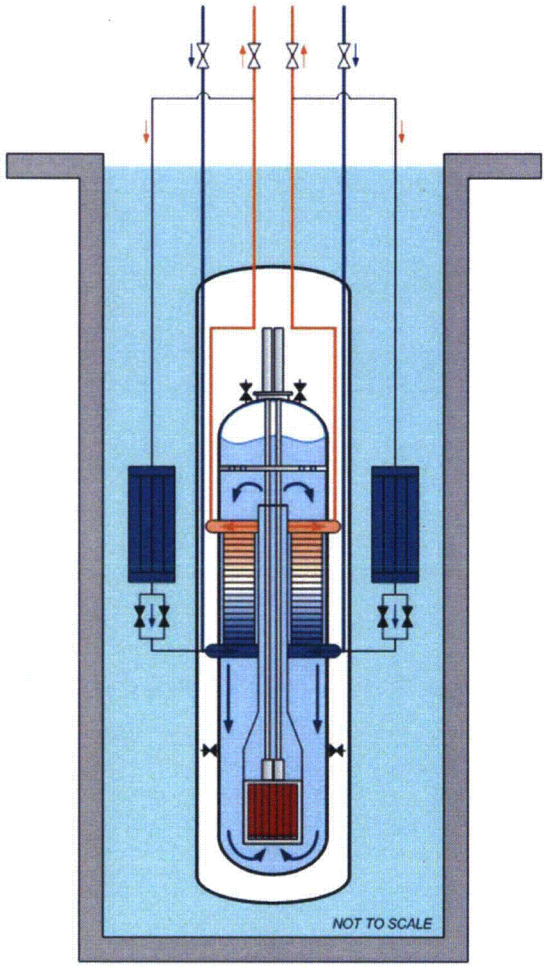
- Natural circulation in the reactor coolant system (RCS)
- Natural circulation in the decay heat removal system (DHRS)
- Natural circulation in the emergency core cooling system (ECCS)

NuScale Power™

DHRS/Isolation Condenser

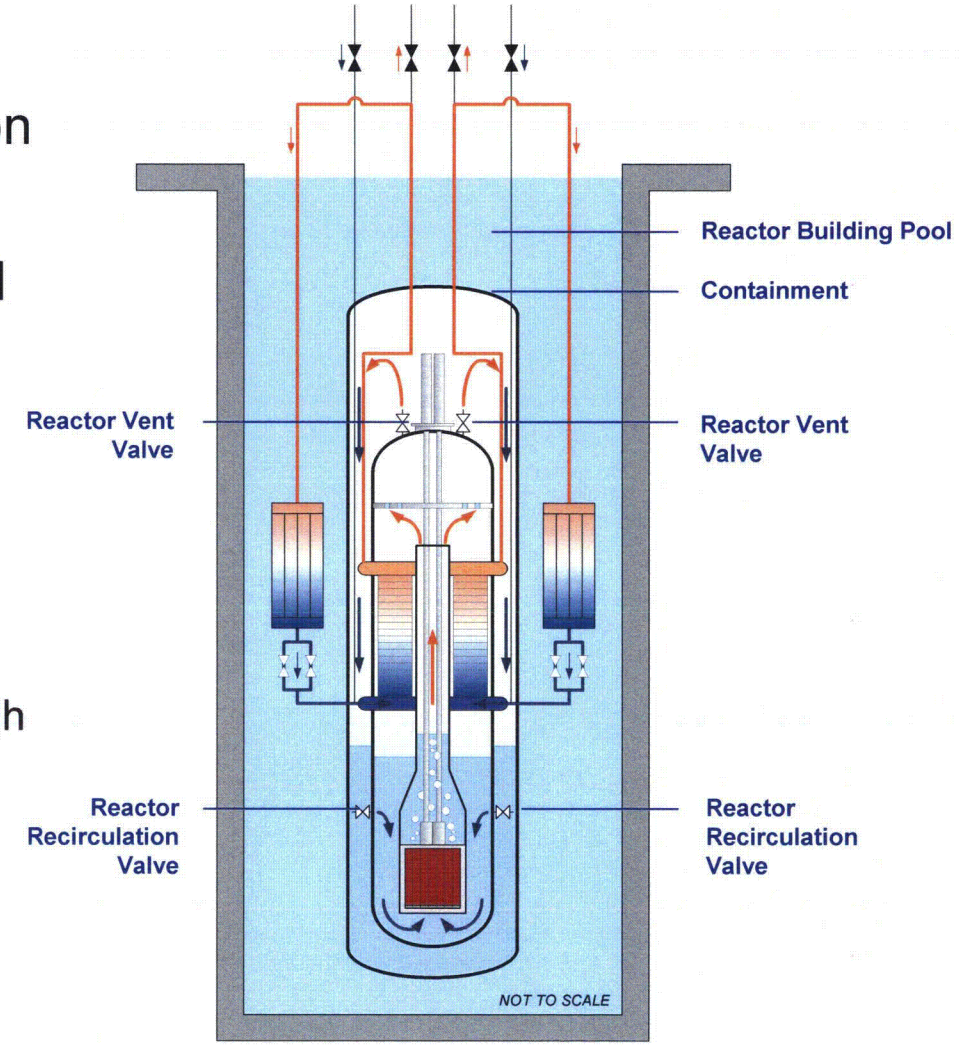


- Main steam and main feedwater isolated
- Decay heat removal (DHR) isolation valves opened
- Decay heat passively removed via the steam generators and DHR heat exchangers to the reactor pool



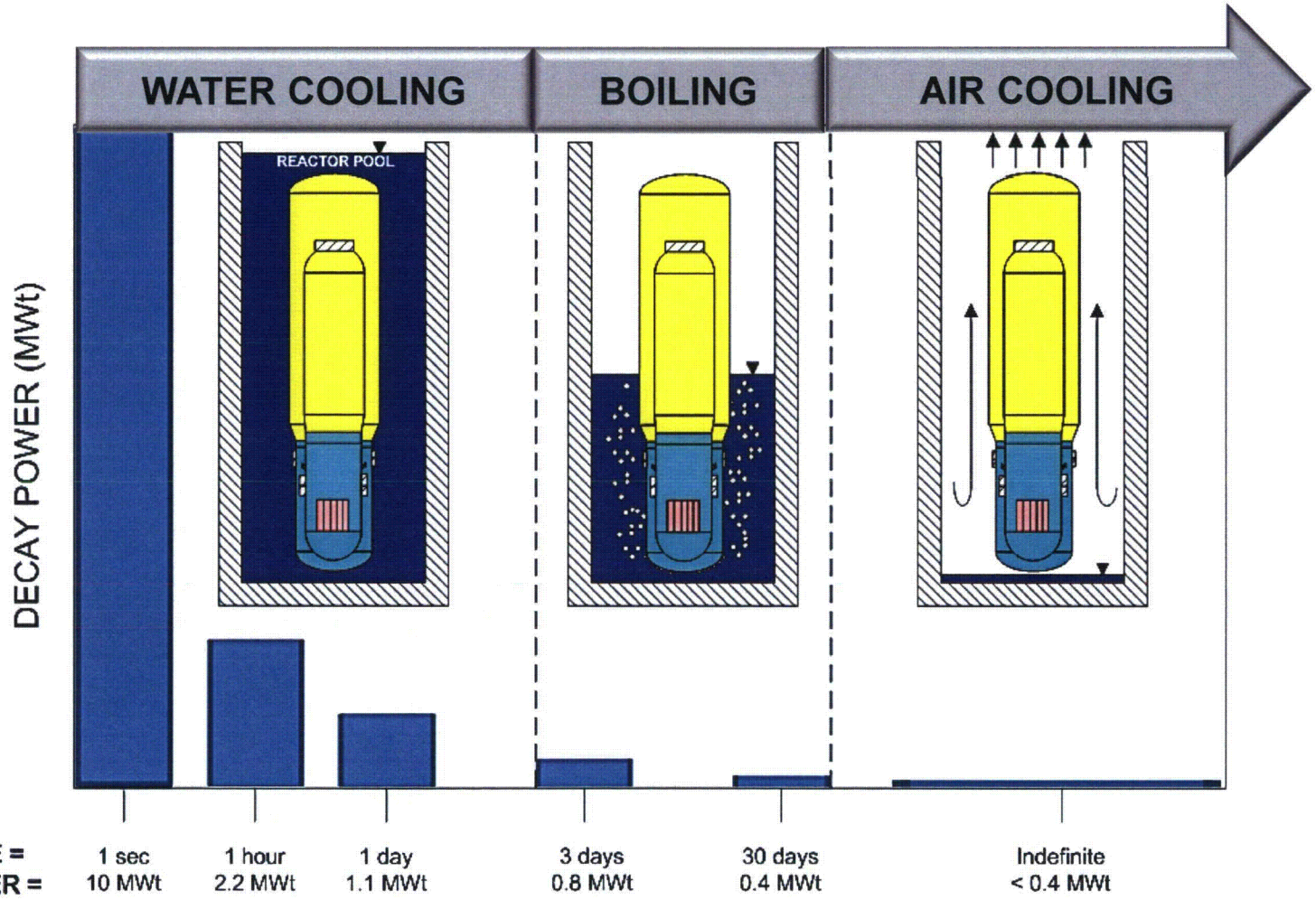
ECCS/Containment Heat Removal

- Reactor vent valves opened on safety signal
- When containment liquid level is high enough, reactor recirculation valves open
- Decay heat removed:
  - condensing steam on inside surface of containment vessel
  - convection and conduction through liquid and both vessel walls



Stable Long-Term Cooling Without Pumps or Power

- Containment and fuel cooled indefinitely for all 12 modules without pumps or power.



NuScale Power™

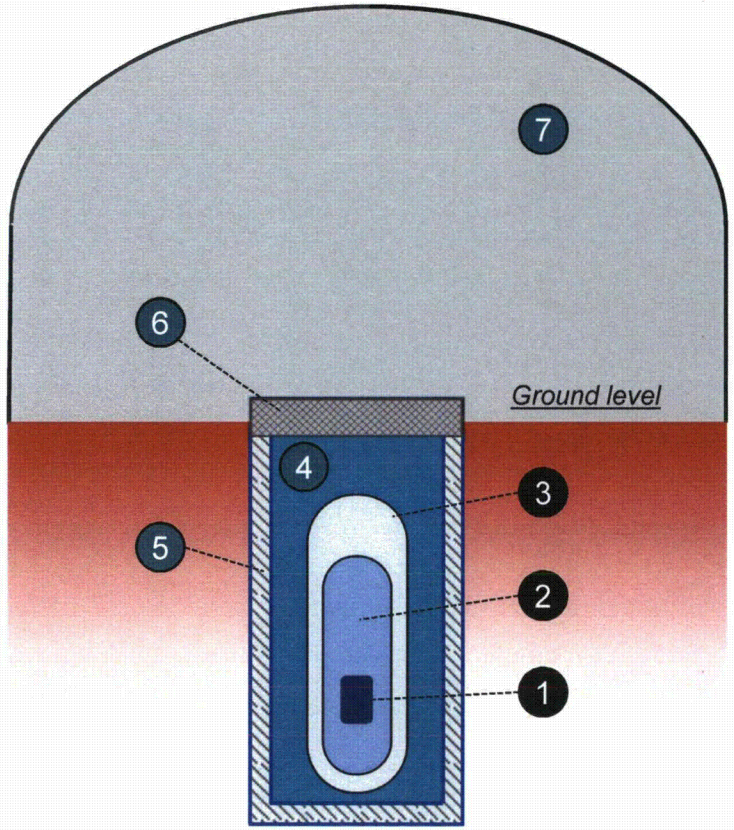
Barriers Between Fuel and Environment

Conventional Designs

1. Fuel pellet and cladding
2. Reactor vessel
3. Containment

Additional Features in NuScale Design

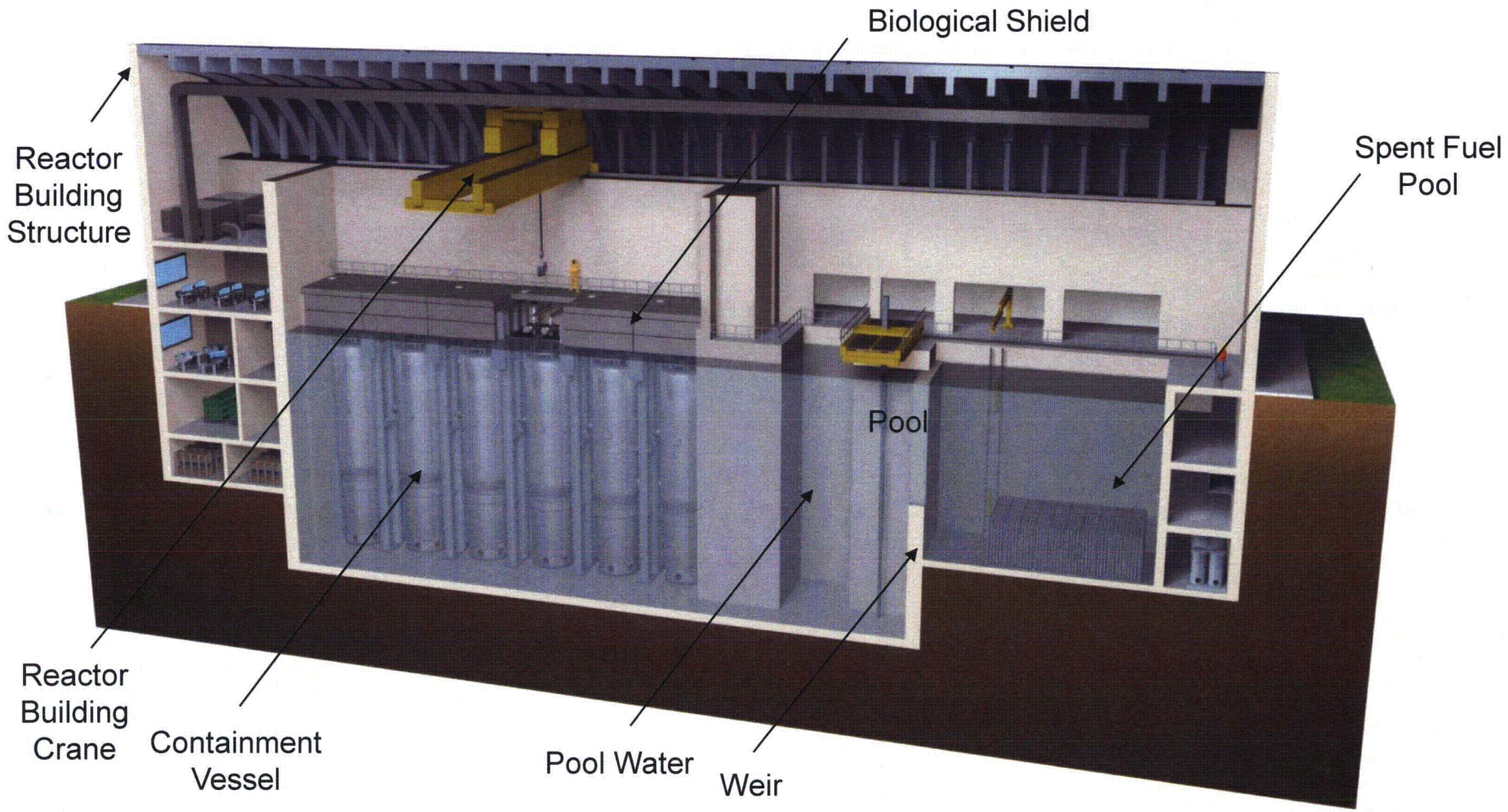
4. Water in reactor pool (10 million gallons)
5. Stainless steel lined concrete reactor pool
6. Biological shield covers each reactor
7. Reactor building (Seismic Category I)



NuScale Power™

Reactor Building

Reactor building houses reactor modules, spent fuel pool, and reactor pool.



NuScale Power™

Containment Vessel Functional Requirements

- Heat transfer related functional requirements
- Pressure and fission product containment
- Other functional requirements

Heat Transfer Functional Requirements

- Transfer heat to ultimate heat sink (UHS) during accidents
  - Submerged containment maximizes transfer of heat to pool water (UHS).
  - Residual heat removal using passive heat transfer (natural circulation)
    - Condensation, conduction, and convection to pool water
      - » DHR and ECC systems

Heat Transfer Functional Requirements

- Minimize heat loss during normal operation
  - The NuScale design functions effectively, like a vacuum bottle - no insulating material.
    - Precludes accumulation of accident-generated debris (GSI-191)
    - Maintaining watertight containment vessel (CNV) vacuum minimizes presence of non-condensable gas, thereby enhancing heat transfer during accidents

Pressure and Fission Product Containment

- Contain fission products released from reactor coolant pressure boundary
  - Design pressure and temperature significantly higher than a typical operating light water reactor (LWR) containment
    - Smaller volume
  - Designed to withstand the jet impingement force from safety relief valve and ECCS valve actuation

Pressure and Fission Product Containment

- Provide necessary containment penetrations
  - Typical operating large LWR containments have over 50 penetrations.
  - NuScale containments have approximately 30 penetrations.
  - Penetrations are smaller in the NuScale CNV.

Pressure and Fission Product Containment

- Allow control of combustible gas
  - –High design pressure and temperature vessel
  - –Containment vessel atmosphere evacuated
    - Very little oxygen in containment
- Withstand prolonged contact with borated water
  - –Corrosion resistant cladding/coating on interior and exterior surfaces

Pressure and Fission Product Containment

- Withstand 60-year integrated exposure to neutron and gamma radiation fluence
  - Use of low-alloy steel
  - Design goal of no welds in highest neutron and gamma fluence region

Other Functional Requirements

- Allow surveillance capability for containment vessel
  - Utilize 10 CFR 50, Appendix H as guidance for containment surveillance program
    - Conservative surveillance criteria (compared to typical containment structures)
    - Analysis scope, material, and fabrication more similar to reactor vessels than typical containments

Other Functional Requirements

- Allow integrated leak-rate testing
  - Compliance strategy under development
- Allow access to perform refueling
  - Module relocated and disassembled for refueling
- Support of reactor vessel and associated components
  - Analysis ongoing for support methodology

Questions and Next Steps

- Functional requirements current as of today
- Containment design evolving
  - Design decisions being made
- Design-Specific Review Standard development
- Future NRC interactions