Auxiliary Systems
Chapter 9

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Nonproprietary

NuScale Power™

NP-PM-0713-4191-NP

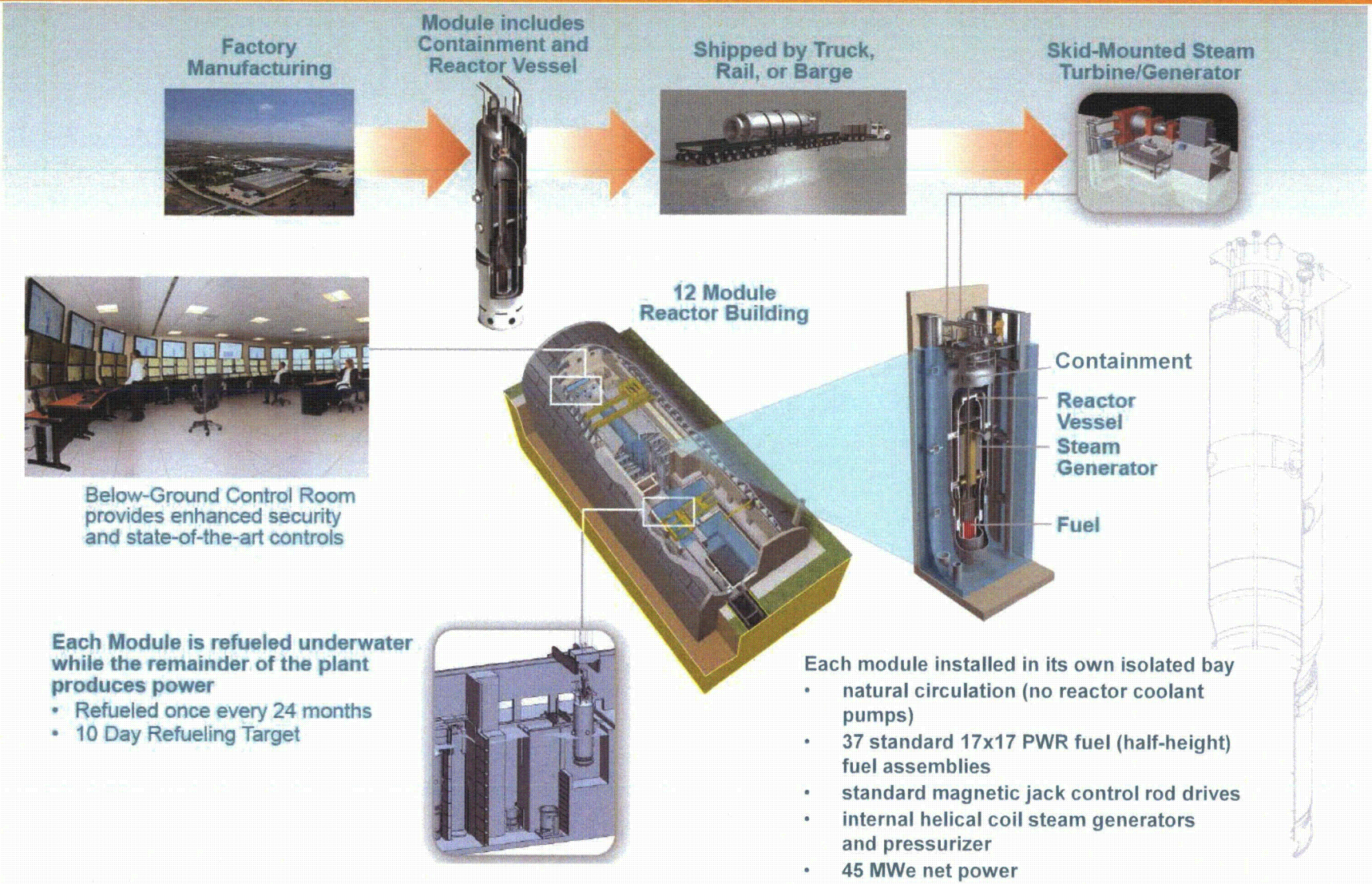
Agenda

- Purpose
- Plant overview
- Background
- Auxiliary systems (except ventilation systems)
  - Design information
  - SRP/DSRS information
- Results achieved and path forward

Purpose

- Provide sufficient information, section-by-section, for development of NuScale DSRS for Chapter 9
  - Design information—auxiliary systems
  - SRP/DSRS information—NRC review guidance for NuScale
- Identify need for future DSRS Chapter 9 engagements

Plant Overview



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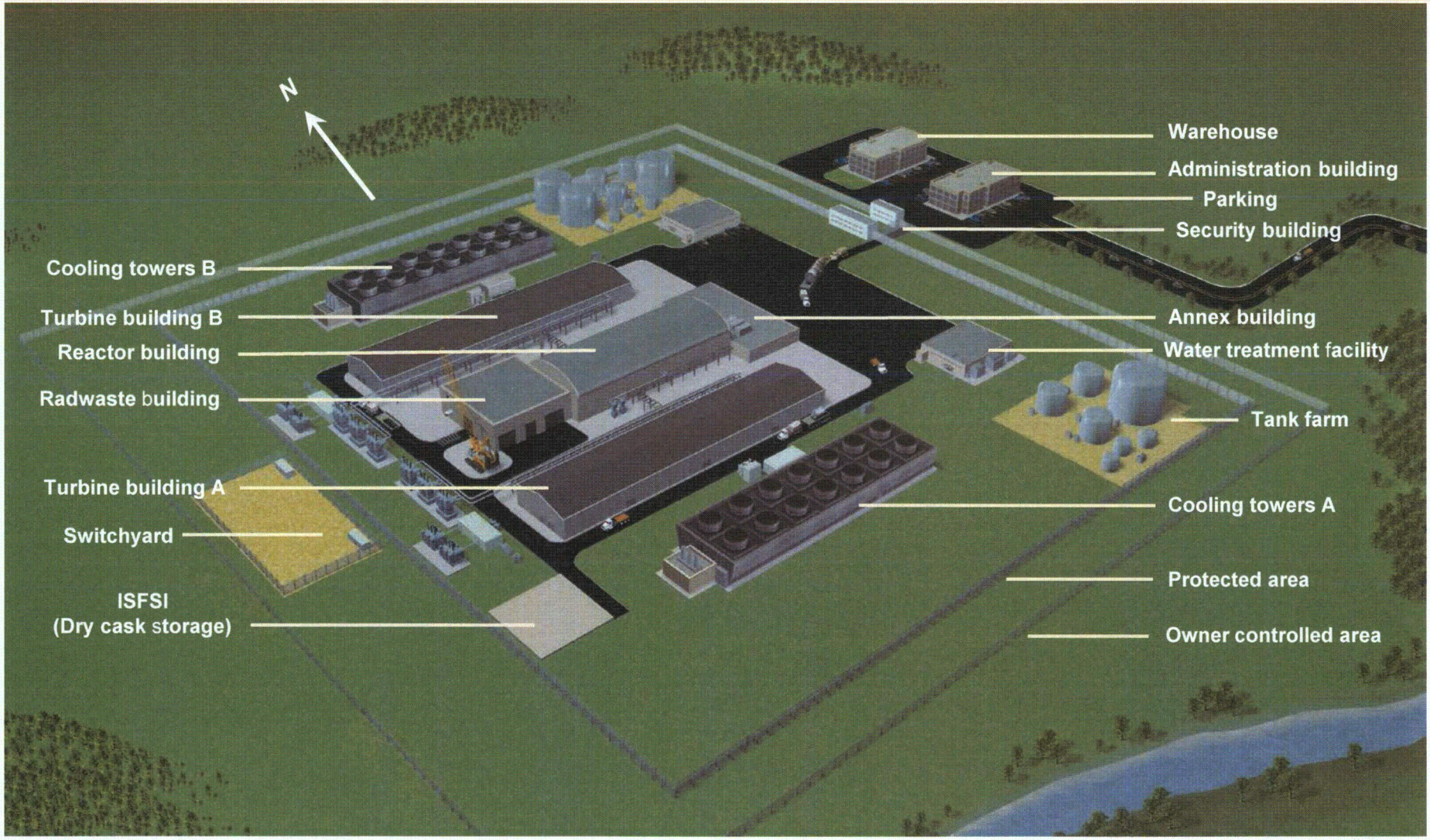
Site Aerial View



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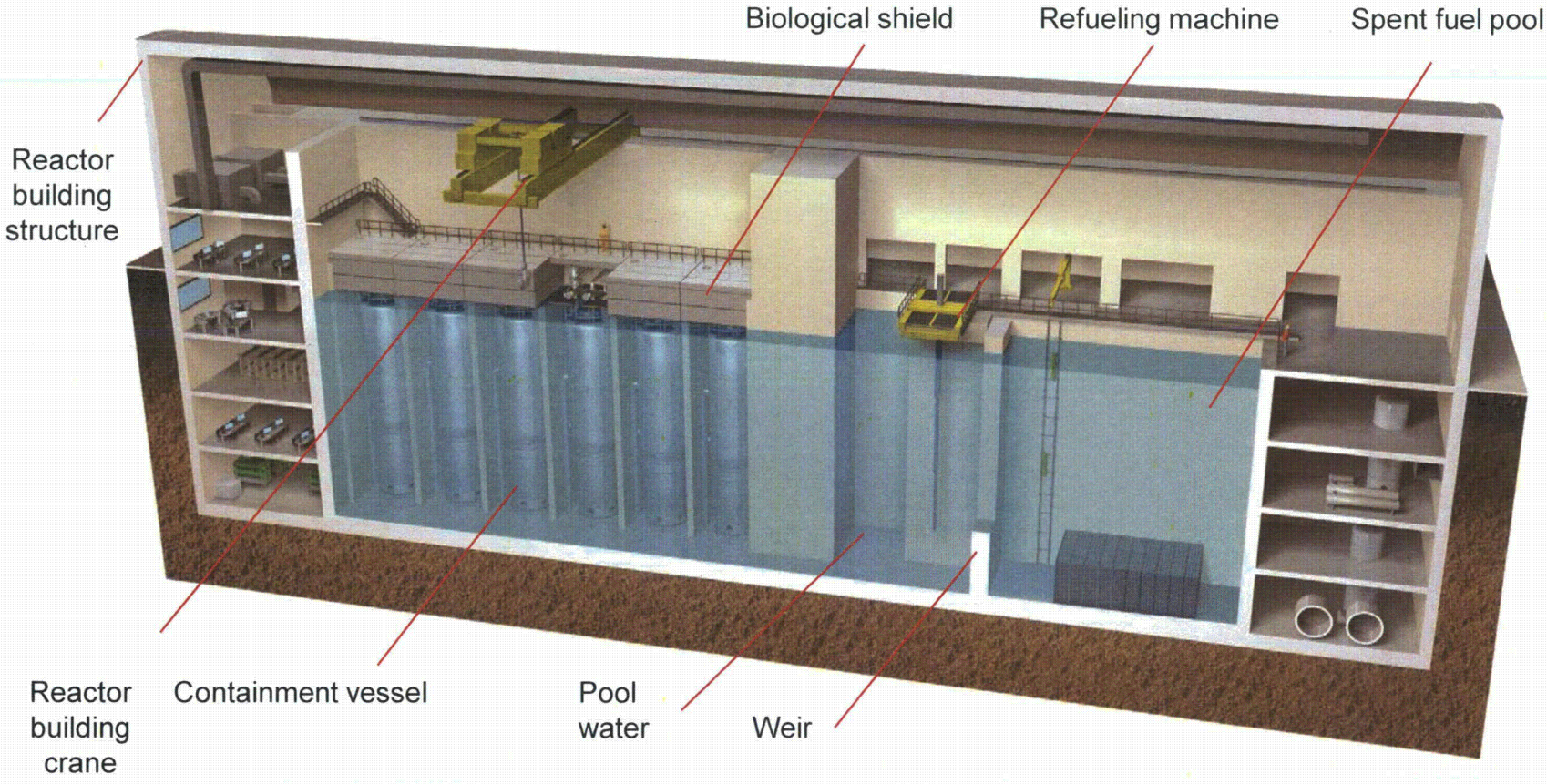
Reactor Building Cross-Section

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



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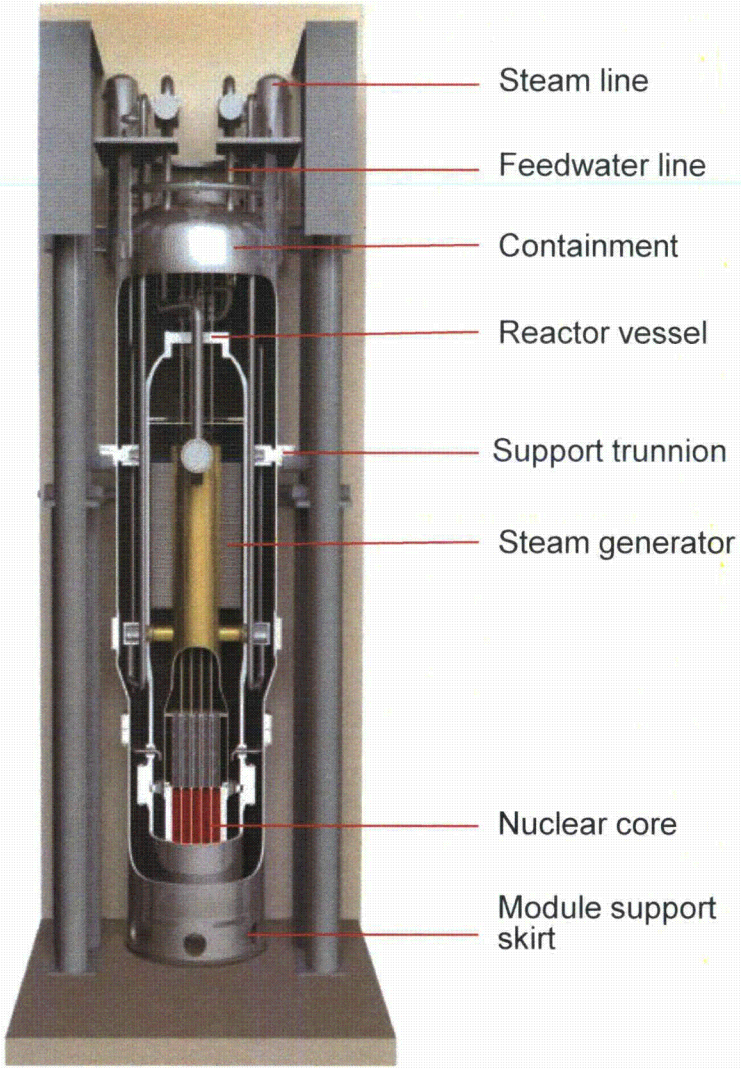
Reactor Module Overview

Natural convection for cooling

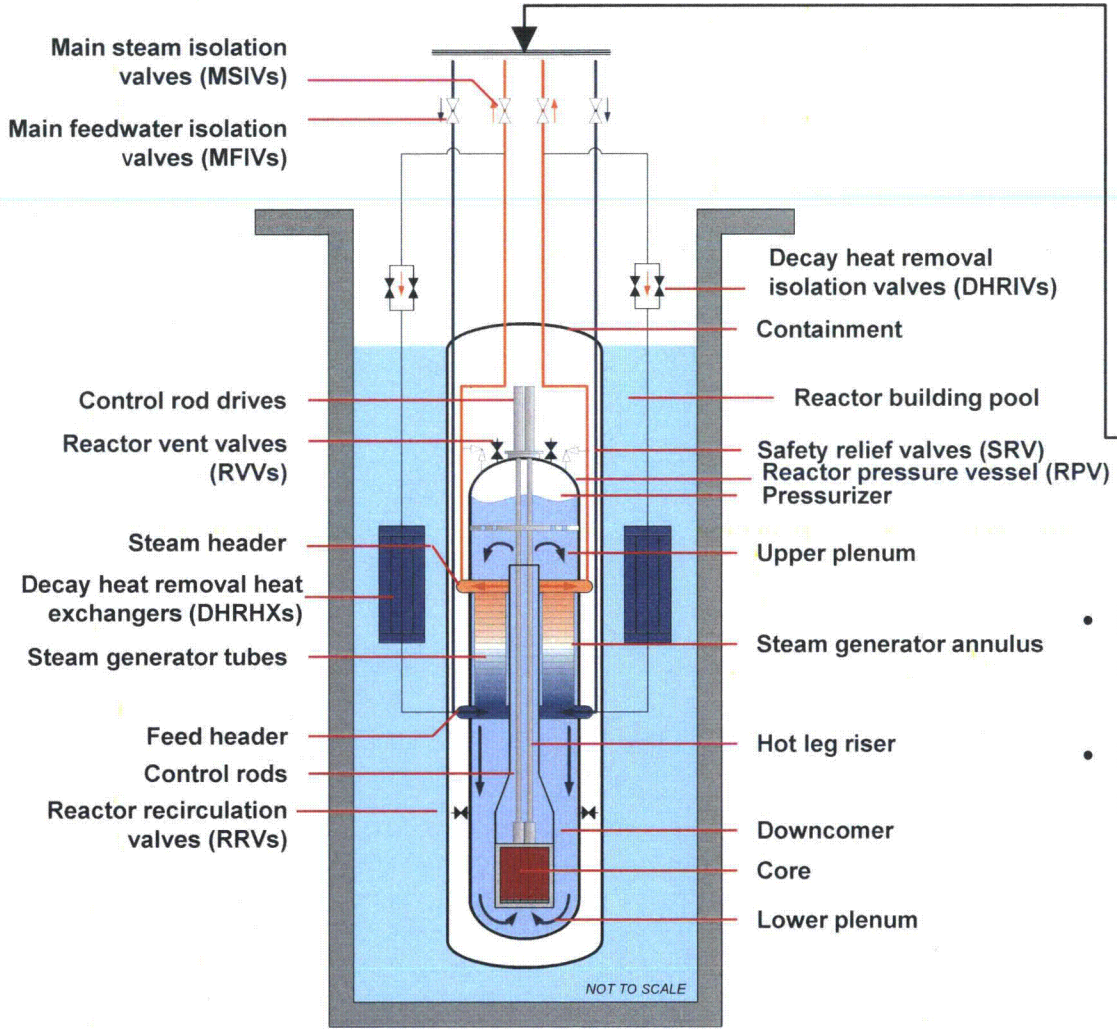
- passively safe, driven by gravity, natural circulation of water over the fuel
- no pumps, no need for emergency generators

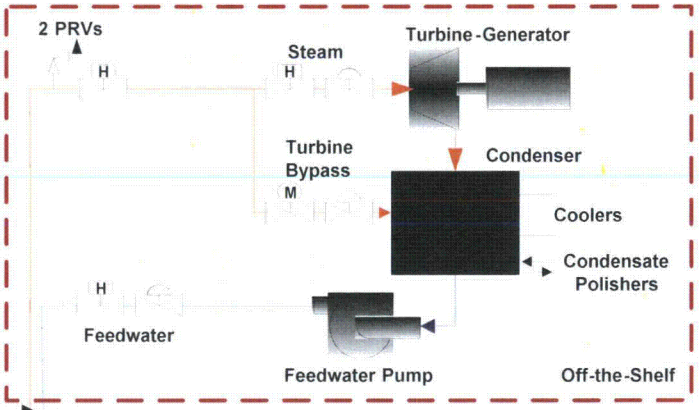
Simple and small

- reactor is 1/20th the size of large reactors
- integrated reactor design, no large-break loss-of-coolant accidents



NuScale Power Train





- Each reactor module feeds one T-G train eliminating single-shaft risk
- Small, simple components support short simple refueling outages

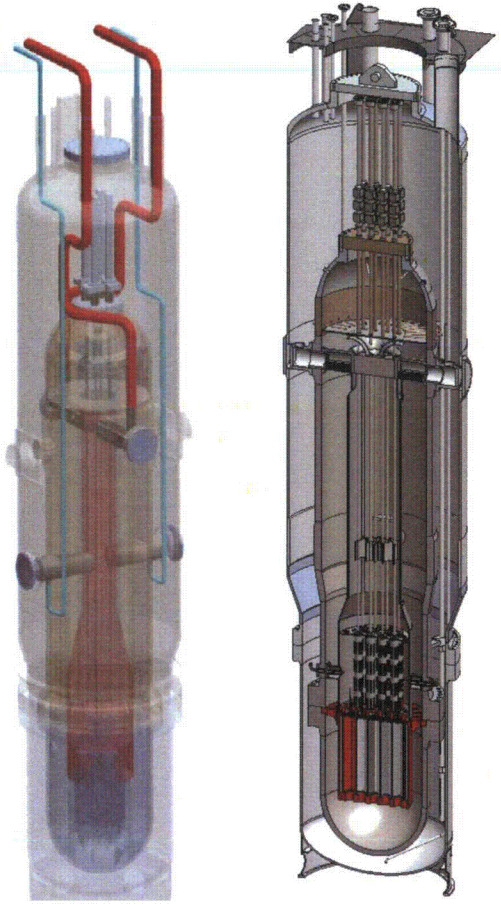
Basic Plant Parameters

Overall Plant	
• Net electrical output	Up to 540 MW(e)
• Plant thermal efficiency	> 28%
• Number of power generation units	Up to 12
• Nominal plant capacity factor	> 90%
Power Generation Unit	
• Number of reactors	One
• Net electrical output	45 MWe
• Steam generator number	Two independent tube bundles
• Steam generator type	Vertical helical tube
• Steam cycle	Superheated
• Turbine throttle conditions	3.3 MPa (475 psia)
• Steam flow	67.5 kg/s (536,200 lb/hr)
• Feedwater temperature	149° C (300° F)
Reactor Core	
• Thermal power rating	160 MWt
• Operating pressure	12.7 MPa (1850 psia)
▪ Fuel	UO_2 (< 4.95% U^{235} enrichment)
▪ Refueling interval	24 months

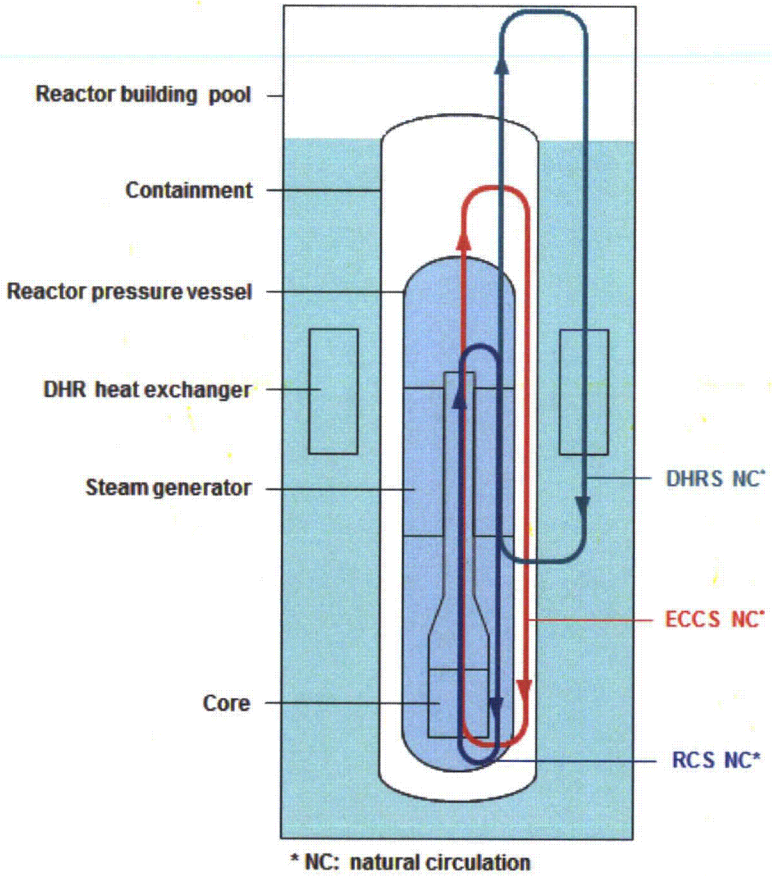
Containment Design

High pressure containment—enhanced safety

- Containment volume sized so that core does not uncover following a LOCA (prevents fuel heat-up)
- Large water pool keeps containment shell cool and promotes efficient post-LOCA steam condensation
- Insulating vacuum
  - significantly reduces conduction and convection heat transfer during normal operation
  - requires no insulation on reactor vessel. Eliminates sump screen blockage issue (GSI-191)
  - improves LOCA steam condensation rates by eliminating air
  - prevents combustible hydrogen mixture in the unlikely event of a severe accident (i.e., little or no oxygen)
  - reduces corrosion and humidity problems inside containment



Plant Overview—Natural Circulation



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

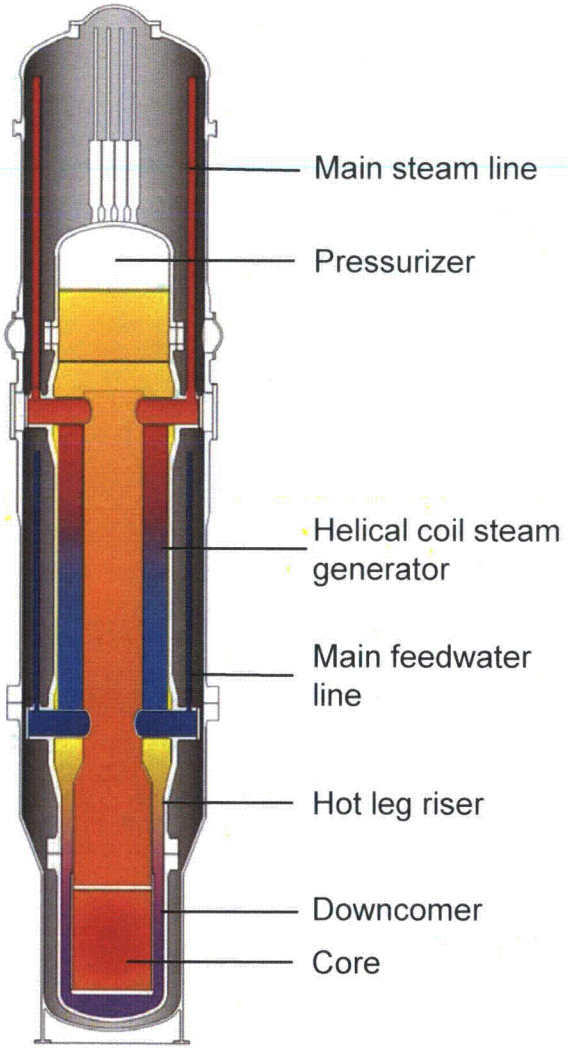
Transient operation

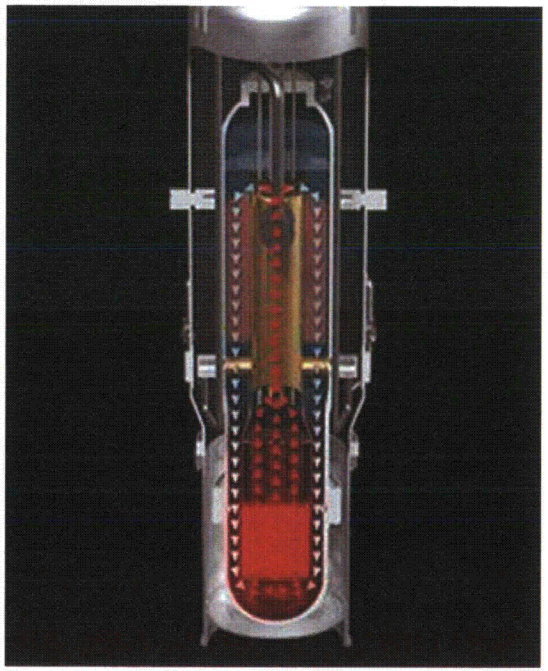
Accident operation

Normal operation

Module Normal Operation

- Primary side
  - natural circulation
  - integral pressurizer
- Secondary side
  - feedwater plenums
  - helical steam generator
  - steam plenums

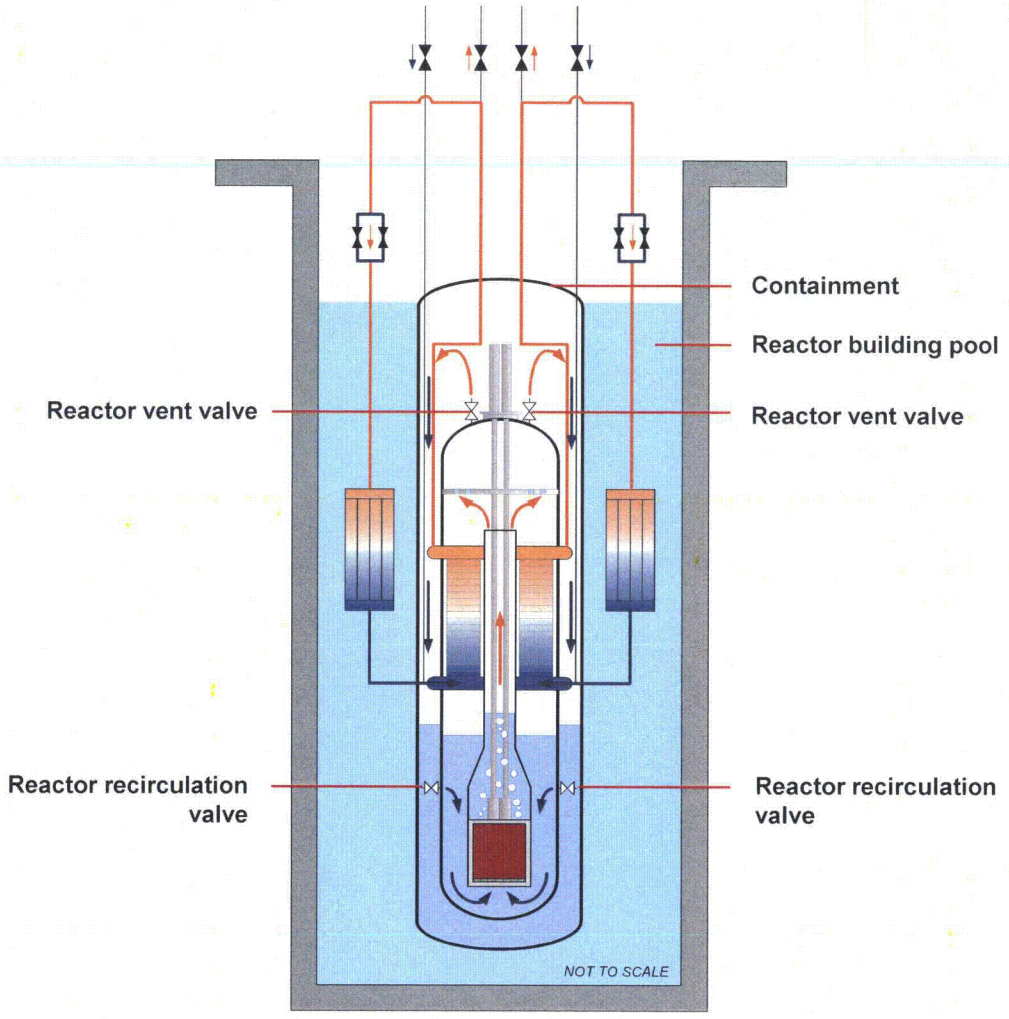




Primary Coolant Flow Path

Emergency Core Cooling and Containment Heat Removal

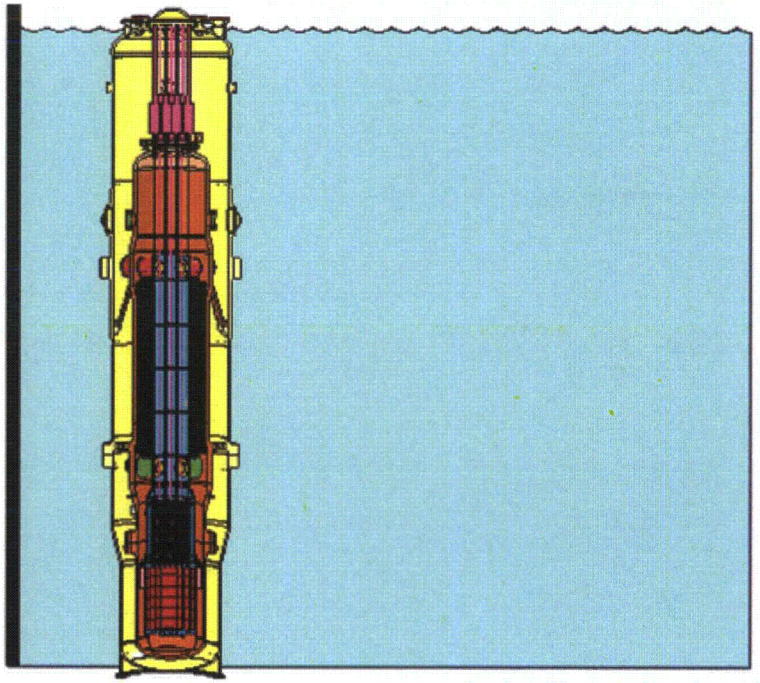
- Reactor vent valves opened on safety signal
- When containment liquid level is high enough, reactor recirculation valves open
- Decay heat removed
  - condensing steam on inside surface of containment vessel
  - convection and conduction through liquid and both vessel walls



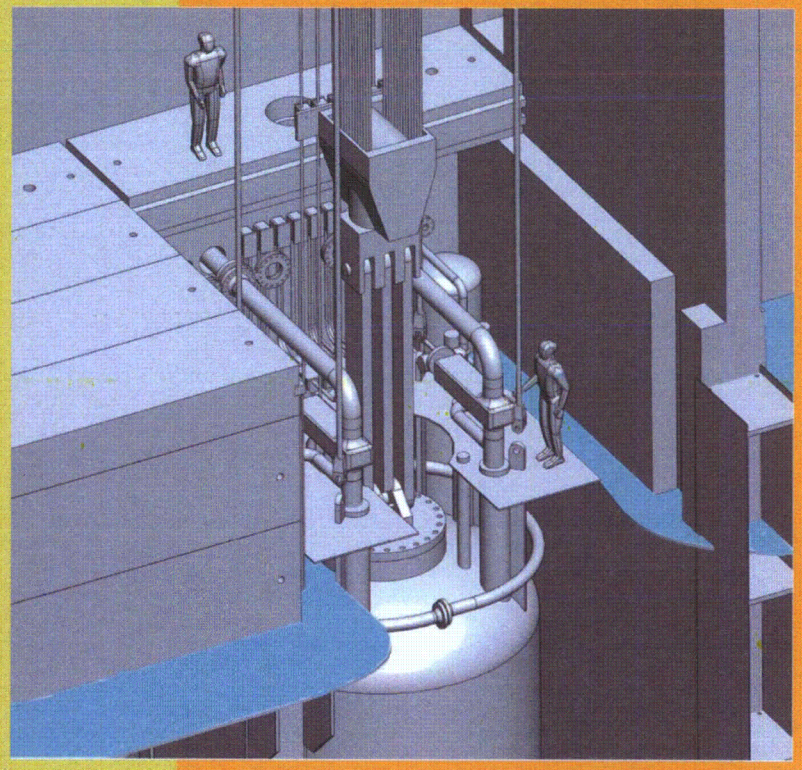
Provide Refueling Access

Provide access for refueling

- move module to refueling bay
- unbolt CNV flange
- remove lower CNV head
- unbolt RPV flange
- move upper RXM to dry dock
- unlatch upper core plate
- remove lower riser assembly
- access fuel



Refueling Cranes and Module Assembly



- Module assembly
  - Modules are transported into the reactor bay and lowered into place
  - Service equipment is located above the reactor pool
- Single failure-proof cranes
  - Allow for refueling
  - Facilitate module installation

Background

- May 2012 meeting: Regulatory Gap Analysis
- July 2012 submittal: Gap Analysis Summary Report
- December 2012 meeting: Regulatory Gap Analysis Results: Regulations Requiring Further Consideration
- May 2013 Federal Register Notice (FRN): mPower DSRS issued for public comment
- June 2013 meeting: NuScale Design-Specific Review Standard Development

DSRS Overview

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DSRS Overview

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DSRS Overview

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Auxiliary Systems

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9.1.2 New and Spent Fuel Storage

- Design information
  - System function and classification

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9.1.2 New and Spent Fuel Storage

- Design information
  - Design overview
    - Shared by all modules (one system)
    - Design is similar in material respects to that of typical reactors
      - » spent fuel pool
      - » spent fuel storage racks
      - » new fuel storage racks
      - » new fuel inspection stand
      - » spent fuel pool liner and leakage detection system
    - New fuel storage and inspection is located adjacent to the spent fuel pool in the reactor building
    - Additional information on fuel handling equipment was provided in the October 4, 2012 presentation slides
  - Documents available for audit

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9.1.2 New and Spent Fuel Storage

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.1.2 with modification
      - See "Additional Comments" for Section 9.1.2 to accommodate single spent fuel pool shared by more than one unit

        http://www.nrc.gov/reactors/advanced/mpower/dsrs/ch9.html
  - NuScale Gap Analysis use as-is
  - Information for NRC development of NuScale DSRS
    - New and spent fuel storage design information
    - Accommodation for single spent fuel pool shared by more than one unit
    - NuScale Gap Analysis results

9.1.3 Pool Support Systems

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9.1.3 Pool Support Systems

- Design information
  - System function and classification

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9.1.3 Pool Support Systems

- Design information
  - Design overview
    - Shared by all modules (one set of systems)

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9.1.3 Pool Support Systems

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9.1.3 Pool Support Systems

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9.1.3 Pool Support Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.1.3 with modification
  - NuScale Gap Analysis remains partially applicable, but is being revised to reflect additional pool support systems
  - Information for NRC development of NuScale DSRS
    - Pool support system design information
    - NuScale comments on mPower DSRS Section 9.1.3
    - NuScale Gap Analysis updates

9.2.5 Ultimate Heat Sink

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9.2.5 Ultimate Heat Sink

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9.2.5 Ultimate Heat Sink

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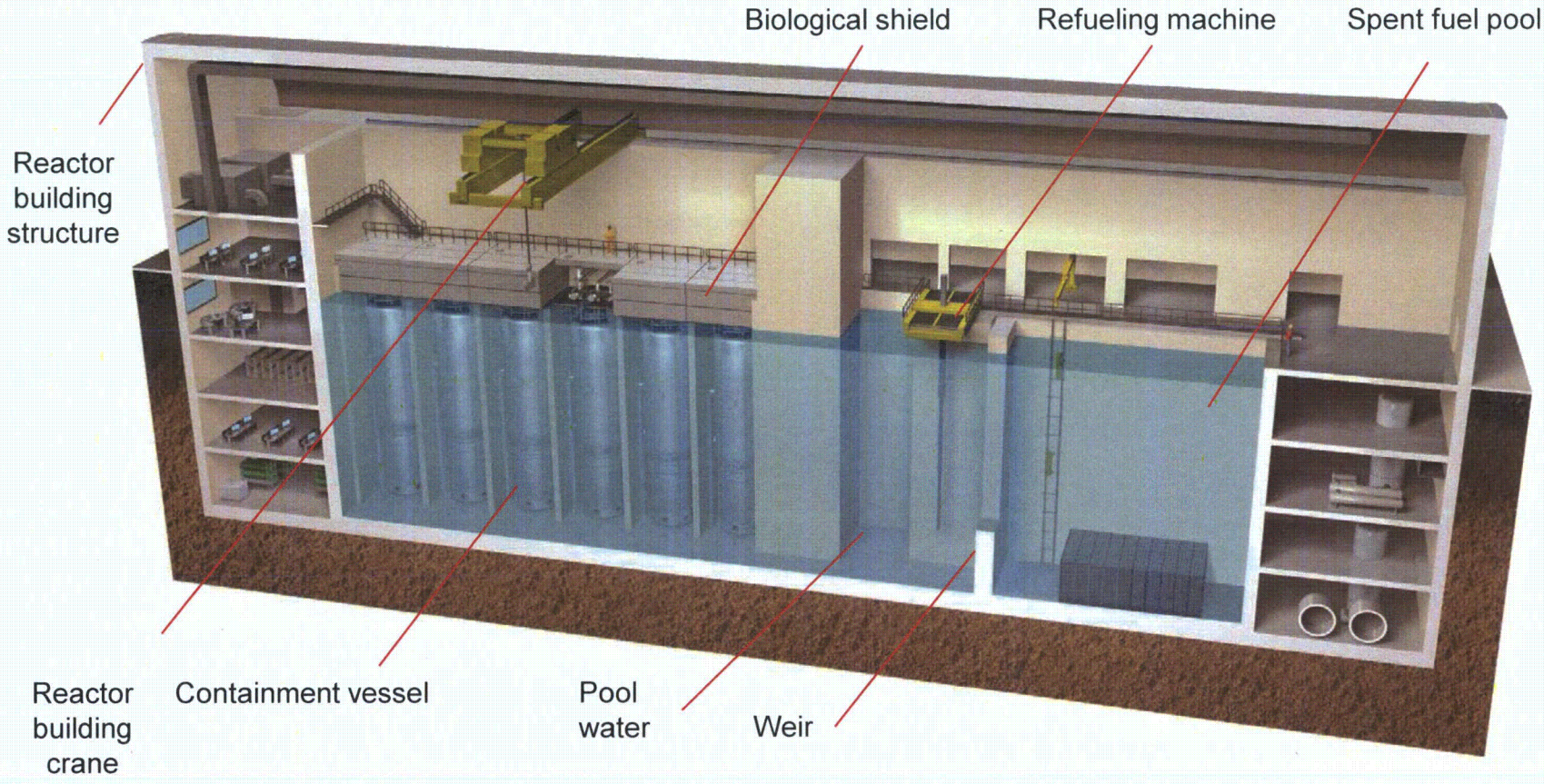
9.2.5 Ultimate Heat Sink

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



9.2.5 Ultimate Heat Sink

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.2.5 with modification
  - NuScale Gap Analysis is being revised from use as-is to partially applicable
  - Information for NRC development of the NuScale DSRS
    - NuScale ultimate heat sink design information
    - NuScale comments on mPower DSRS Section 9.2.5
    - NuScale Gap Analysis updates

9.3.4 Chemical and Volume Control System

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9.3.4 Chemical and Volume Control System

- Design information
  - System function and classification

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9.3.4 Chemical and Volume Control System

- Design information
  - Design overview
    - One system per module (12 systems)
    - Functions of the CVC system are to
      - » purify reactor coolant
      - » increase or decrease the boron concentration in the coolant
      - » provide makeup and discharge capabilities to account for changes in the coolant volume
      - » supply spray flow to the pressurizer to reduce the reactor coolant system (RCS) pressure
      - » allows for chemical addition to the coolant

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  - Documents available for audit

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9.3.4 Chemical and Volume Control System

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9.3.4 Chemical and Volume Control System

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.3.4 with modification
  - NuScale Gap Analysis remains "use with modification"
  - Information for NRC development of the NuScale DSRS
    - NuScale chemical and volume control system design information
    - NuScale Gap Analysis results

9.3.6 Containment Evacuation System

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9.3.6 Containment Evacuation System

- Design information
  - Svstem function and classification

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  - Design overview
    - One system per module (12 systems)
    - The containment evacuation system is designed to affect and monitor the conditions in the containment vessel space. Functions include

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9.3.6 Containment Evacuation System

- Documents available for audit

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9.3.6 Containment Evacuation System

- SRP/DSRS information
  - Current NuScale assessment
    - New Section 9.3.6 for NuScale DSRS
  - NuScale Gap Analysis
    - No assessment, since no SRP section exists specific to this system
    - Updated to indicate new NuScale DSRS Section 9.3.6
  - Information for NRC development of the NuScale DSRS
    - NuScale containment evacuation system design information

DSRS Overview

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DSRS Overview

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DSRS Overview

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9.2.1 Station Service Water System

- Design information
  - System function and classification
    - See site cooling water system design information for Section 9.2.7
  - Design overview
    - NuScale site cooling water system analogous to the non-essential portion of a typical service water system
    - See site cooling water system design information for Section 9.2.7
  - Documents available for audit
    - See site cooling water system design information for Section 9.2.7

9.2.1 Station Service Water System

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.2.1 with modification
  - NuScale Gap Analysis changing from not applicable to partially applicable
  - Information for NRC development of the NuScale DSRS
    - NuScale site cooling water system design information
    - At NRC request, design information for any other systems the NRC plans to review using Section 9.2.1
    - NuScale comments on mPower DSRS Section 9.2.1
    - NuScale Gap Analysis updates

9.2.2 Reactor Auxiliary Cooling Water Systems

- Design information
  - System function and classification

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9.2.2 Reactor Auxiliary Cooling Water Systems

- Design information
  - Design overview
    - Shared by all modules (one system)
    - Components include

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9.2.2 Reactor Auxiliary Cooling Water Systems

- Design information
  - Documents available for audit

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9.2.2 Reactor Auxiliary Cooling Water Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.2.2 with modification
  - NuScale Gap Analysis remains partially applicable
  - Information for NRC development of NuScale DSRS
    - NuScale design information for reactor component cooling water system
    - At NRC request, design information for any other systems the NRC plans to review using Section 9.2.2
    - NuScale comments on mPower DSRS Section 9.2.2
    - NuScale Gap Analysis updates

9.2.4 Potable and Sanitary Water Systems

- Design information
  - System function and classification

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  - Design overview
    - Site system
    - Design scope limited for DC application (i.e., conceptual design information)
  - Documents available for audit

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9.2.4 Potable and Sanitary Water Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.2.4 with modification
  - NuScale Gap Analysis is being revised from use as-is to partially applicable
  - Information for NRC development of the NuScale DSRS
    - NuScale potable and sanitary water systems design information
    - NuScale comments on mPower DSRS Section 9.2.4
    - NuScale Gap Analysis updates

9.2.6 Condensate Storage Facilities

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9.2.6 Condensate Storage Facilities

- Design information
  - System function and classification

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  - Design overview
    - One system per module (12 systems)

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  - Documents available for audit

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9.2.6 Condensate Storage Facilities

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.2.6 with modification
  - NuScale Gap Analysis remains "partially applicable"
  - Information for NRC development of the NuScale DSRS
    - NuScale condensate storage facility design information
    - NuScale comments on mPower DSRS Section 9.2.6
    - NuScale Gap Analysis updates

9.2.7 Site Cooling Water System

- Design information
  - System function and classification

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  - Design overview
    - Site system

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  - Documents available for audit

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9.2.7 Site Cooling Water System

- SRP/DSRS information
  - Current NuScale assessment
    - Use NuScale DSRS Section 9.2.1
  - NuScale Gap Analysis
    - No assessment, since no SRP Section 9.2.7 exists specific to this system
    - To be revised to indicate that NuScale DSRS Section 9.2.1 to be applied to site cooling water system
  - Information for NRC development of the NuScale DSRS
    - See slides for Section 9.2.1

9.2.8 Chilled Water System

- Design information
  - System function and classification

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  - Design overview
    - Site system

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  - Documents available for audit

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9.2.8 Chilled Water System

- SRP/DSRS information
  - Current NuScale assessment
    - Use NuScale DSRS Section 9.2.1 and/or 9.2.2
  - NuScale Gap Analysis
    - No assessment, since no SRP Section 9.2.8 exists specific to this system
    - Updated to indicate that NuScale DSRS Section 9.2.1 and/or 9.2.2 to be applied to chilled water system
  - Information for NRC development of the NuScale DSRS
    - See slides for Sections 9.2.1 and 9.2.2

9.2.9 Balance of Plant Component Cooling Water System

- Design information
  - System function and classification

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  - Design overview
    - Shared by six modules (two systems)

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  - Documents available for audit

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9.2.9 Balance of Plant Component Cooling Water System

- SRP/DSRS information
  - Current NuScale assessment
    - Use NuScale DSRS Section 9.2.1 and/or 9.2.2
  - NuScale Gap Analysis
    - No assessment, since no SRP Section 9.2.9 exists specific to this system
  - Information for NRC development of the NuScale DSRS
    - See slides for Sections 9.2.1 and 9.2.2

9.2.10 Demineralized Water System

- Design information
  - System function and classification

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  - Design overview
    - Site system
    - Typical system design—demineralized water system provides adequate quality and quantity of demineralized water to plant users
  - Documents available for audit

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9.2.10 Demineralized Water System

- SRP/DSRS information
  - Current NuScale assessment
    - Use NuScale DSRS Section 9.2.1 and/or 9.2.2
  - NuScale Gap Analysis
    - No assessment, since no SRP Section 9.2.10 exists specific to this system
    - To be revised to indicate that NuScale DSRS Section 9.2.1 and/or 9.2.2 to be applied to the demineralized water system
  - Information for NRC development of the NuScale DSRS
    - See slides for Sections 9.2.1 and 9.2.2

9.2.11 Raw Water and Utility Water Systems

- Design information
  - System function and classification

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  - Design overview
    - Site system
    - Typical system design—{{

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  - Documents available for audit

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9.2.11 Raw Water and Utility Water Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use NuScale DSRS Section 9.2.1 and/or 9.2.2
  - NuScale Gap Analysis
    - No assessment, since no SRP Section 9.2.11 exists specific to these systems
    - To be revised to indicate that NuScale DSRS Section 9.2.1 and/or 9.2.2 to be applied to the raw water and utility water systems
  - Information for NRC development of the NuScale DSRS
    - See slides for Sections 9.2.1 and 9.2.2

9.5.4–9.5.8 Diesel Generator Engine Support Systems

- Design information
  - System function and classification

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9.5.4–9.5.8 Diesel Generator Engine Support Systems

- Design information

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9.5.4–9.5.8 Diesel Generator Engine Support Systems

- Design information
  - Design overview
    - One set of site systems
    - Industry standard system designs

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9.5.4–9.5.8 Diesel Generator Engine Support Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Sections 9.5.4–9.5.8 with modification
  - NuScale Gap Analysis is being revised from not applicable to partially applicable
    - Portions governing safety-related SSCs are not relevant
    - Modifications to reflect RTNSS Criterion B
  - Information for NRC development of the NuScale DSRS
    - NuScale BDG engine support system design information
    - NuScale Gap Analysis updates

9.1.1 Criticality Safety of Fresh and Spent Fuel Storage and Handling

- Design information
  - System function and classification

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  - Design overview
    - Shared by all modules (one system)

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    - Key analysis parameters include
      - » New fuel racks—K_{eff} < 0.95 at 95 percent probability and confidence levels. Up to 5 percent enriched fuel.
      - » Spent fuel racks—K_{eff} < 0.95 with unborated water, capacity for 15 years of operation plus assemblies for 12 NuScale Power Module cores
  - Documents available for audit

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9.1.1 Criticality Safety of New and Spent Fuel Storage and Handling

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.1.1 as-is
  - NuScale Gap Analysis remains use as-is
  - Information for NRC development of the NuScale DSRS
    - Not applicable

9.1.4 Light Load Handling System

- Design information
  - System function and classification

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  - Design overview
    - Shared by all modules (one system)
    - Additional system information was provided in the October 4, 2012 presentation
  - Documents available for audit

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9.1.4 Light Load Handling System

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.1.4 as-is (minor changes)
  - NuScale Gap Analysis remains use as-is
  - Information for NRC development of the NuScale DSRS
    - NuScale light load handling system design information

9.1.5 Heavy Load Handling System

- Design information
  - System function and classification

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  - Design overview
    - Shared by all modules (one system)
    - Additional system information was provided in the October 4, 2012 presentation
  - Documents available for audit

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9.1.5 Heavy Load Handling System

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.1.5 with modifications
  - NuScale Gap Analysis remains use as-is
  - Information for NRC development of the NuScale DSRS
    - NuScale heavy load handling system design information

9.3.1 Compressed Air System

- Design information
  - System function and classification

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  - Design overview
    - Site system
    - Typical system design
  - Documents available for audit

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9.3.1 Compressed Air System

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.3.1 as-is (minor changes)
  - NuScale Gap Analysis remains use as-is
  - Information for NRC development of the NuScale DSRS
    - NuScale compressed air system design information
    - NuScale Gap Analysis results

9.3.2 Process and Post-Accident Sampling Systems

- Design information
  - System function and classification

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  - Design overview
    - One system per module (12 systems)
    - Typical system design—process and post-accident sampling systems
      - » Obtain liquid and gas samples from primary systems for monitoring and analysis of chemical and radiochemical conditions

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  - Documents available for audit

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9.3.2 Process and Post-Accident Sampling Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.3.2 with modification
  - NuScale Gap Analysis is being revised from use-as-is to use with modification
  - Information for NRC development of the NuScale DSRS
    - NuScale sampling system design information
    - NuScale comments on mPower DSRS Section 9.3.2
    - NuScale Gap Analysis updates

9.3.3 Equipment and Floor Drainage System

- Design information
  - Svstem function and classification

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  - Design overview
    - Site system
    - Typical system design—equipment and floor drainage systems comprise the {{

}}3(a)-(c)

  - Documents available for audit

{{

}}3(a)-(c)

9.3.3 Equipment and Floor Drainage System

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.3.3 with modification
  - NuScale Gap Analysis remains use as-is
  - Information for NRC development of the NuScale DSRS
    - NuScale equipment and floor drainage system design information
    - NuScale Gap Analysis results

9.5.1.1 Fire Protection Program

- Design information
  - System function and classification

{{

}}3(a)-(c)

  - Design overview
    - Site system
  - Documents available for audit

{{

}}3(a)-(c)

9.5.1.1 Fire Protection Program

- SRP/DSRS information
  - Current NuScale assessment
    - Use SRP Section 9.5.1.1 with modification
    - SRP Section 9.5.1.2 (risk-informed fire protection) not applicable
  - NuScale Gap Analysis remains "use with modification"
  - Information for NRC development of the NuScale DSRS
    - NuScale fire protection design information
    - NuScale Gap Analysis results

9.5.2 Communication Systems

- Design information
  - System function and classification

{{

}}3(a)-(c)

  - Design overview
    - Site system
  - Documents available for audit

{{

}}3(a)-(c)

9.5.2 Communication Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.5.2 (minor changes)
  - NuScale Gap Analysis remains "use with modification"
  - Information for NRC development of the NuScale DSRS
    - NuScale communication system design information
    - NuScale comments on mPower DSRS Section 9.5.2
    - NuScale Gap Analysis results

9.5.3 Lighting Systems

- Design information
  - System function and classification

{{

}}3(a)-(c)

  - Design overview
    - Site system
    - No design at this time
  - Documents available for audit

{{ }}3(a)-(c)

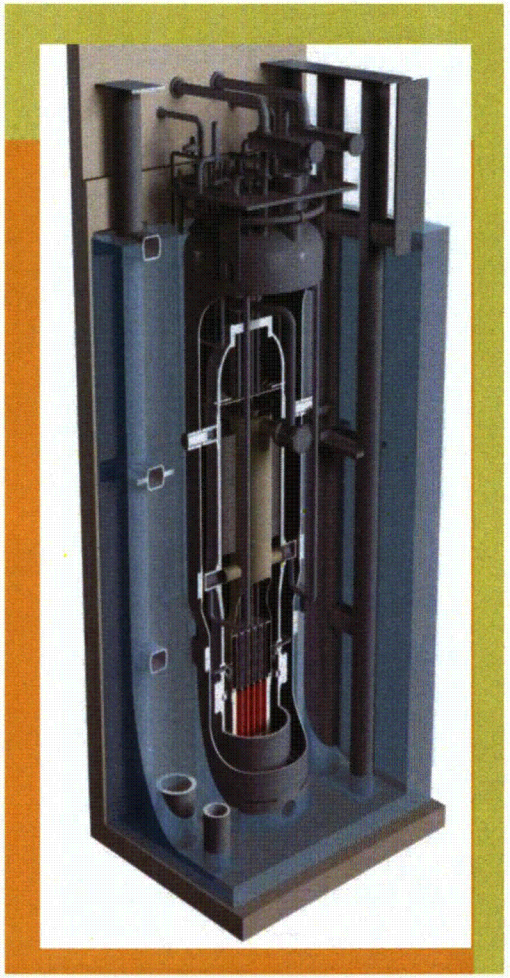
9.5.3 Lighting Systems

- SRP/DSRS information
  - Current NuScale assessment
    - Use mPower DSRS Section 9.5.3 (minor changes)
  - NuScale Gap Analysis is being revised from use as-is to use with modification
  - Information for NRC development of the NuScale DSRS
    - NuScale lighting system design information
    - NuScale Gap Analysis results

Results Achieved and Path Forward

- Provided information for development of NuScale DSRS for Chapter 9
  - design information—auxiliary systems
  - SRP/DSRS information—NRC review guidance for NuScale
- Plan for future auxiliary systems interactions

NuScale Power™



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