NuScale Power, LLC

Severe Accident Analysis
Nonproprietary

Severe Accident Analysis

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Agenda

- Purpose of the meeting
- Background
- Severe accident analysis approach
- Preliminary analysis results
- Feedback and next steps

Purpose

- Provide the U.S. Nuclear Regulatory Commission (NRC) with an understanding of NuScale's approach to severe accident event selection and analysis approach
- Provide early severe accident scenario results
- Obtain NRC feedback
  - Event selection approach
  - Analysis tools
  - Severe accident phenomena/issues

Background

- Previous interactions
  - September 2009, Severe Accident Presentation in Rockville
  - June 2010, Probabilistic Risk Assessment (PRA) Overview in Rockville
  - March 2011, PRA and Severe Accidents Overview in Corvallis

Background

Regulatory Guidance

- 10 CFR 52.47(a)(23)
- NUREG-0800, Chapter 19
- SECY-90-016
- SECY-93-087 identifies the following:
  - Hydrogen control
  - Core debris coolability
  - High pressure melt ejection
  - Containment bypass and performance
  - Equipment survivability

Background

Probabilistic risk assessment standards

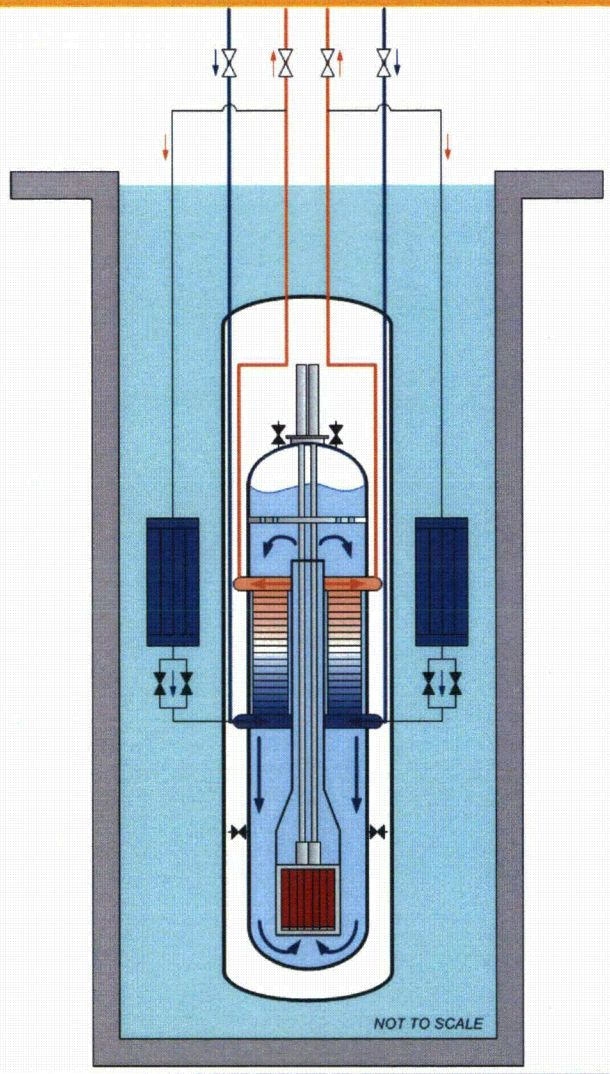
- Level-1 internal and external events: ASME/ANS RA-Sa-2009 "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," February 2009.
  - PRA Standard will be followed to the extent feasible
- Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," Rev. 2, March 2009.
- Low power and shutdown (ANS-58.22-200x)

Background

- NRC State-of-the-art Reactor Consequence Analysis (SOARCA)
  - Best-estimate offsite consequences for potential severe accidents
  - State-of-the-art computational analysis tools
  - Current best modeling practices
  - Core damage frequency (CDF) used as a surrogate selection criterion for risk

Design Features for Severe Accident Prevention and Mitigation

- Primary System
  - Robust system depressurization
  - Passive, natural circulation, decay heat removal systems
  - Chemical and volume control system (CVCS) charging capability
  - Steam generator tubes under compression
  - No reactor pressure vessel (RPV) insulation
  - Small core and source term
- Containment
  - Strong vacuum during normal operations
  - High pressure steel containment
  - Passive containment heat removal
- Large reactor cooling pool/ultimate heat sink



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Severe Accident Analysis Approach

- Conceptual design PRA developed
- Severe accident phenomena identification and ranking table (PIRT)
- Expert review of identified phenomena
- Scoping analysis of key phenomena
- Deterministic analysis of severe accidents
- Inform the design process and update as the design changes

Probabilistic Risk Assessment

- Probabilistic risk assessment identified accident scenarios that lead to core damage:
  - Based on conceptual design
  - Identified dominant contributors to CDF
  - Rationale applied to select set of severe accidents for closer examination

- Severe accident scenarios selected:
  - Significantly contributed to total core damage frequency
  - Address NRC policy issues
  - Provide additional challenging behavior

Probabilistic Risk Assessment

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Severe Accident PIRT

Severe accident PIRT provided early identification of key phenomena on which to focus.

- PIRT developed in February 2009
  - Dr. Mike Corradini, Chair (Professor, University of Wisconsin)
  - Dr. Joy Rempe (Fellow, Idaho National Laboratory)
  - Dr. Vijay Dhir (Dean of Engineering, UCLA)
  - Dr. Jose Reyes (CTO, NuScale Power)

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- Preliminary RELAP5 scoping calculations presented to panel

Severe Accident PIRT

PIRT results

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Severe Accident PIRT

Risk-Informed Design Insights

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Expert Review of Phenomena

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Preliminary Scoping Results for Key Phenomena

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Deterministic Severe Accident Analysis

- Deterministic calculations
  - Performed using MELCOR 1.8.6
  - Level of detail and general modeling consistent with current best practices
- Code and model benchmarking and qualification
  - Benchmark results against safety analysis code results
  - Expert peer review
  - Evaluate applicability of existing data
  - Uncertainty analysis

MELCOR Analysis Model

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Preliminary SA Analysis

- Three scenarios identified by severe accident PIRT panel analyzed

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High Pressure Transient

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High Pressure Transient

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High Pressure Transient

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CVCS LOCA Outside Containment

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CVCS LOCA Outside Containment

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CVCS LOCA Outside Containment

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CVCS LOCA Outside Containment

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CVCS LOCA Outside Containment

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Steam Generator Tube Break

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Steam Generator Tube Break

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Steam Generator Tube Break

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Steam Generator Tube Break

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Steam Generator Tube Break

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Preliminary Analysis Observations

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Preliminary Analysis Observations

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Summary and Next Steps

- Systematic approach to selecting severe accident scenarios
- State-of-the-art computational analysis tools
- Continuing to update models and analysis and inform the design process
- Severe Accident Mitigation Guidelines
- Future NRC engagement