Loss-of-Coolant Accident Phenomena Identification and Ranking Table

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Outline

- Requirements
- Purpose and Scope
- Plant Description
- Scenario
- Process
- Results
- Conclusions

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Requirements & Interfaces

- 10 CFR 50.46, *Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors*
- SECY-08-189, *Advanced Reactor Design Policy*
- Regulatory Guide 1.203, *Transient and Accident Analysis Methods*
- NuScale Level B Software Quality Assurance Process & Procedures

Purpose and Scope

- Independent assessment of the relative importance of phenomena that may occur in the NuScale module during postulated loss-of-coolant accidents (LOCAs)
- Support development of detailed evaluation models for analysis of LOCAs

Plant Description

- Based on Rev. A module design
- Key differences between Rev A. and Rev. C (current) designs
  - 2 m core/power increased to 160 MWt from 150 MWt
  - ECCS timing
  - Steam generator tube number & dimensions
  - Volume in lower region of containment vessel decreased
  - Vent valve sizing
  - Detailed primary system and core internal designs

Scenario Description

- Loss of coolant accident variation in the NuScale design is restricted by the limited number of penetrations of the primary system pressure boundary
  - Breaks in penetrations that would exceed normal makeup capacity
- Leads to a very limited set of LOCA scenarios
- Panel selected an inadvertent actuation of an RVV as a scenario that would cover the vast majority of phenomena to be expected in any LOCA
- Sample RELAP5/3.3 calculations were developed to help inform the panel deliberations

Process

- Step 1 – Issues
- Step 2 – Objectives
- Step 3 – Hardware and Scenario
- Step 4 – Evaluation Criteria
- Step 5 – Knowledge Base
- Step 6 – Identify Phenomena
- Step 7 – Important Ranking
- Step 8 – Knowledge Level Ranking

Panelists

- Dr. Graham Wallis, Chair
- Dr. Lawrence E. Hochreiter
- Dr. Mujid S. Kazimi
- Mr. Brent Boyack
- Dr. Kord S. Smith
- Dr. José N. Reyes
- Dr. Kent B. Welter, Facilitator
- Dr. Eric P. Young, Assistant

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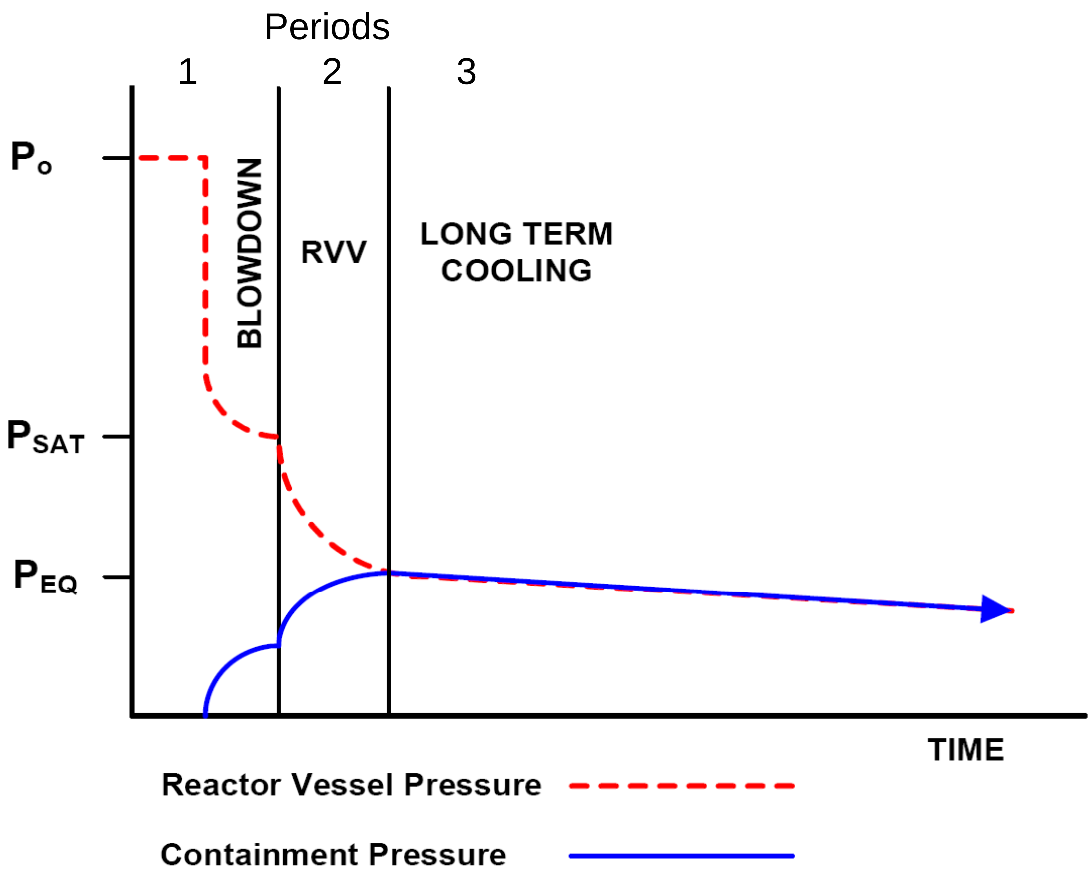
Important Level & Knowledge Rankings

Importance Rank	Definition
Inactive (I)	Phenomenon not present or negligible
Low (L)	Small influence on primary figure of merit
Medium (M)	Moderate influence on primary figure of merit
High (H)	Significant influence on primary figure of merit

Knowledge Level	Definition
1	Very limited knowledge, uncertainty cannot be characterized
2	Partially known, large uncertainty
3	Known, moderate uncertainty
4	Well known, small uncertainty

Scenario Periods



Phenomena Specific Systems, Components, and Processes

Core	Primary System	Containment Heat Removal System	Decay Heat Removal System
• Fuel Rods • Subchannel Coolant Flow • Core-Wide Flow • Control Rods/ Guide Tubes • Reflector/Core Barrel/Baffle	• Downcomer • Hot Leg Riser • Lower Plenum • Upper Plenum • Pressurizer • Cold Leg (Steam Generator Annulus) • Break	• Containment • Sump Recirculation Valves • Containment Cooling Pool • Reactor Vent Valves • Concrete/Stainless Steel Liner of Containment Cooling Pool	• Containment Cooling Pool (During Sparger Venting) • Sump Screen and Piping • Steam Generator tubes • Sparger and Piping • Feedwater Accumulators • Instrumentation

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Figures of Merit

Period	Figure of Merit	Description
1	Critical heat flux	Thermal limit of a phenomenon where a phase change occurs during heating (such as bubbles forming on a metal surface used to heat water), which suddenly decreases the efficiency of heat transfer, thus causing a localized temperature increase of the heating surface. Also called a departure from nucleate boiling (DNB), the CHF limit for the fuel cladding is an important figure of merit for assessing reactor safety.
2	Core collapsed liquid level and Critical heat flux	Single-phase collapsed liquid level is measured in relation to the top of the heated fuel region. CHF is important for any heated surface within the core region, and is described for the previous period.
3	Core coolability	Conditional configuration described by the ability to supply sufficient coolant to prevent fuel temperatures that would result in fuel damage.

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Summary of Results

	Phase 1 (Initial Blowdown)	Phase 2 (RVV Actuation)	Phase 3 (Long-Term Cooling)
High Importance (H)	Subchannel/coolant flow	Break Reactor vent valves	Concrete/stainless steel liner of CCP
Medium Importance (M)	Fuel rods Core wide flow Hot Leg Riser Lower Plenum Upper Plenum Pressurizer Cold Leg (SG annulus) Break	Fuel rods Subchannel/Coolant Flow Core wide flow Hot Leg Riser Lower Plenum Pressurizer Containment	Break Containment Sump recirculation valves Containment cooling pool Reactor vent valves
Low Importance (L)	Control rods/guide tubes Reflector/core barrel/baffle Downcomer Containment Containment cooling pool while Sparger venting	Control rods/guide tubes Reflector/core barrel/baffle Downcomer Upper Plenum Cold Leg (SG annulus) Containment cooling pool	Fuel rods Subchannel/Coolant Flow Core wide flow Control rods/guide tubes Reflector/core barrel/baffle Downcomer Hot Leg Riser Lower Plenum Upper Plenum Pressurizer Cold leg (SG annulus)

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Conclusions

- Approximately 160 phenomena related to the figures of merit were identified.
- 54 (~34%) were specified as being of high importance for at least one period of the SBLOCA.
- No phenomenon identified is ranked high in importance for all three periods of the SBLOCA.
- The knowledge levels for these 54 highly-ranked phenomena ranged from 2 (partially known) to 4 (fully known), with the large majority of them being ranked as fairly well known.
- 16 phenomena of high importance were assigned the knowledge level of 2
- The majority of the high-importance, low-knowledge phenomena are associated with the core subchannel flow and Hot Leg Riser

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