Confirmatory Testing Investigating Advanced Passive Plant Thermal-Hydraulics

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United States Nuclear Regulatory Commission
Office of Nuclear Regulatory Research

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Outline

- Introduction
- Experimental Facility
- Beyond Design Basis Test Results
- Comparisons
- Summary and Conclusions

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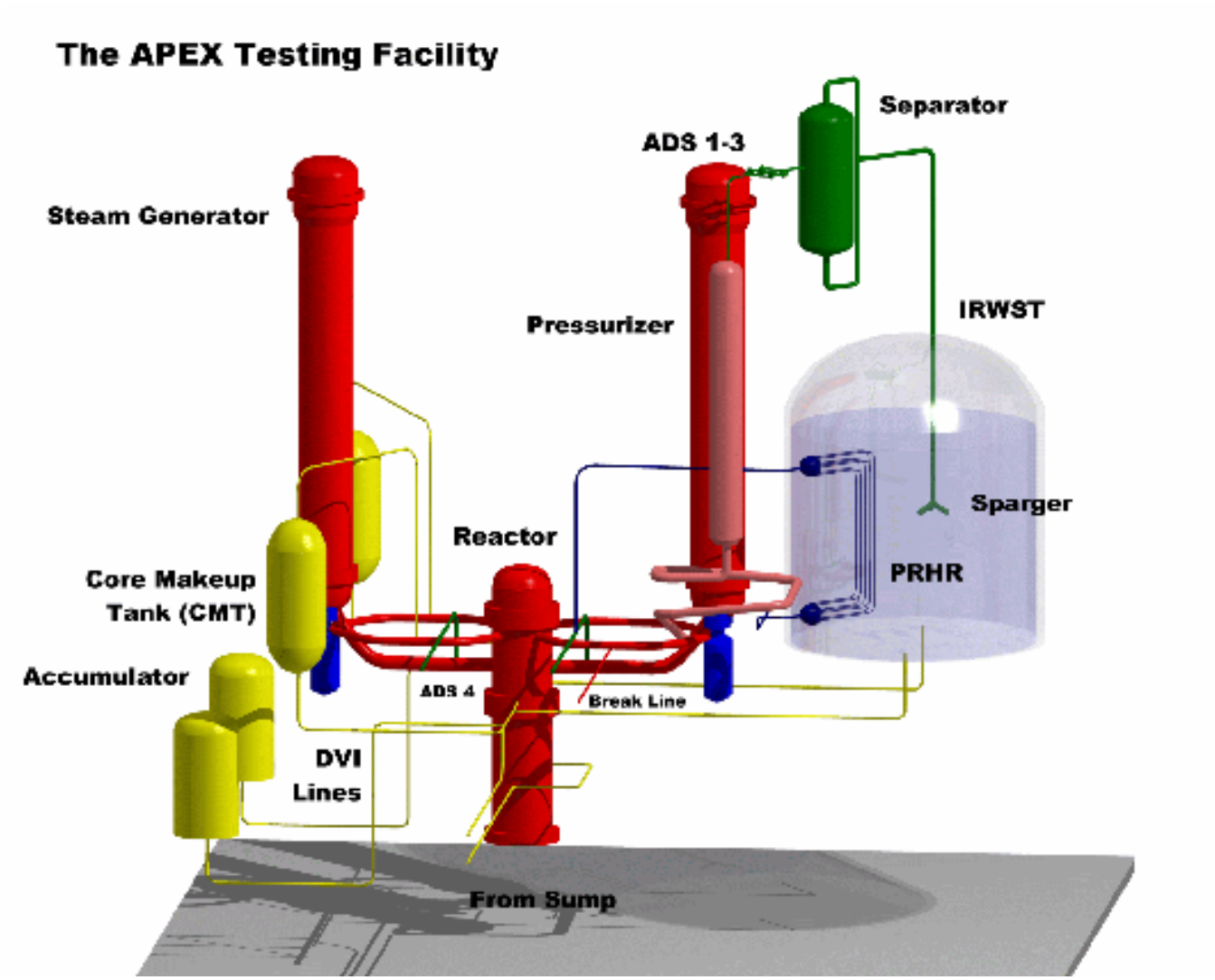
Introduction

- Design Certification Process
- AP1000 Application Received March 2002
- Purpose of Tests
  - Generate Data for Code Assessment
  - Support Confirmatory Analyses
- Modifications to APEX Facility
- Confirmatory Tests Completed by July 2004

Experimental Facility

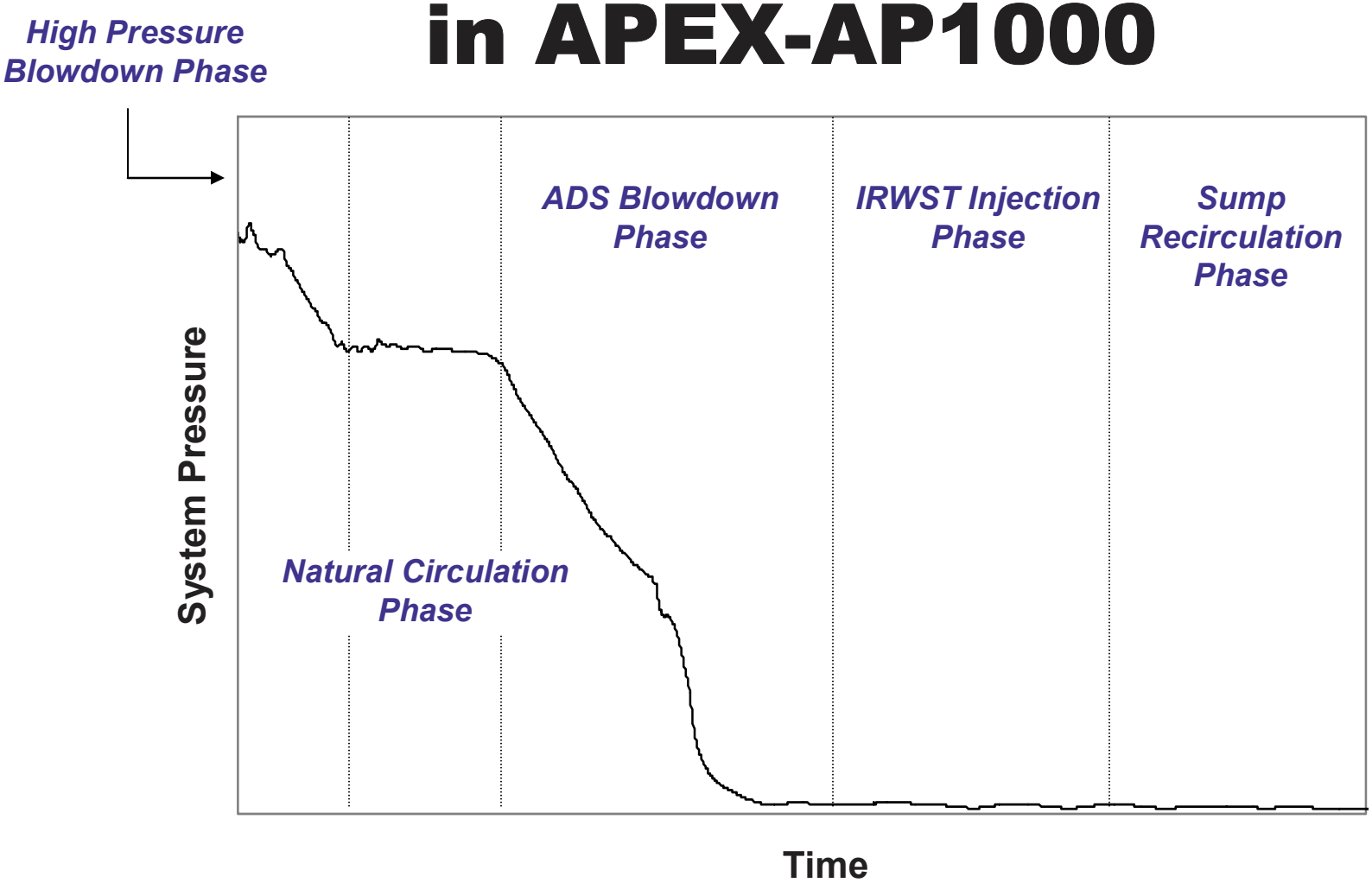
- **Facility:**
  - ¼ Height
  - ½ Time
  - Reduced Pressure
  - Includes Reactor Coolant System, Passive Safety Systems, and Balance of Plant
- **Scaling Analysis**


The APEX Testing Facility
Separator
ADS 1-3
Steam Generator
IRWST
Pressurizer
Sparger
Reactor
PRHR
Core Makeup
Tank (CMT)
Accumulator
ADS 4
Break Line
DVI
Lines
From Sump

Beyond Design Basis Test Matrix

- **DEDVI Line Breaks**
  - **NRC-AP1000-01, 03, and 05**
- **Cold Leg Breaks**
  - **NRC-AP1000-04, 06 and 10**
- **Mode 5 Operation with Loss of RNS Cooling**
  - **NRC-AP1000-02**
- **Station Blackout**
  - **NRC-AP1000-11**
- **Upper Plenum Entrainment**

Typical SBLOCA Transient in APEX-AP1000



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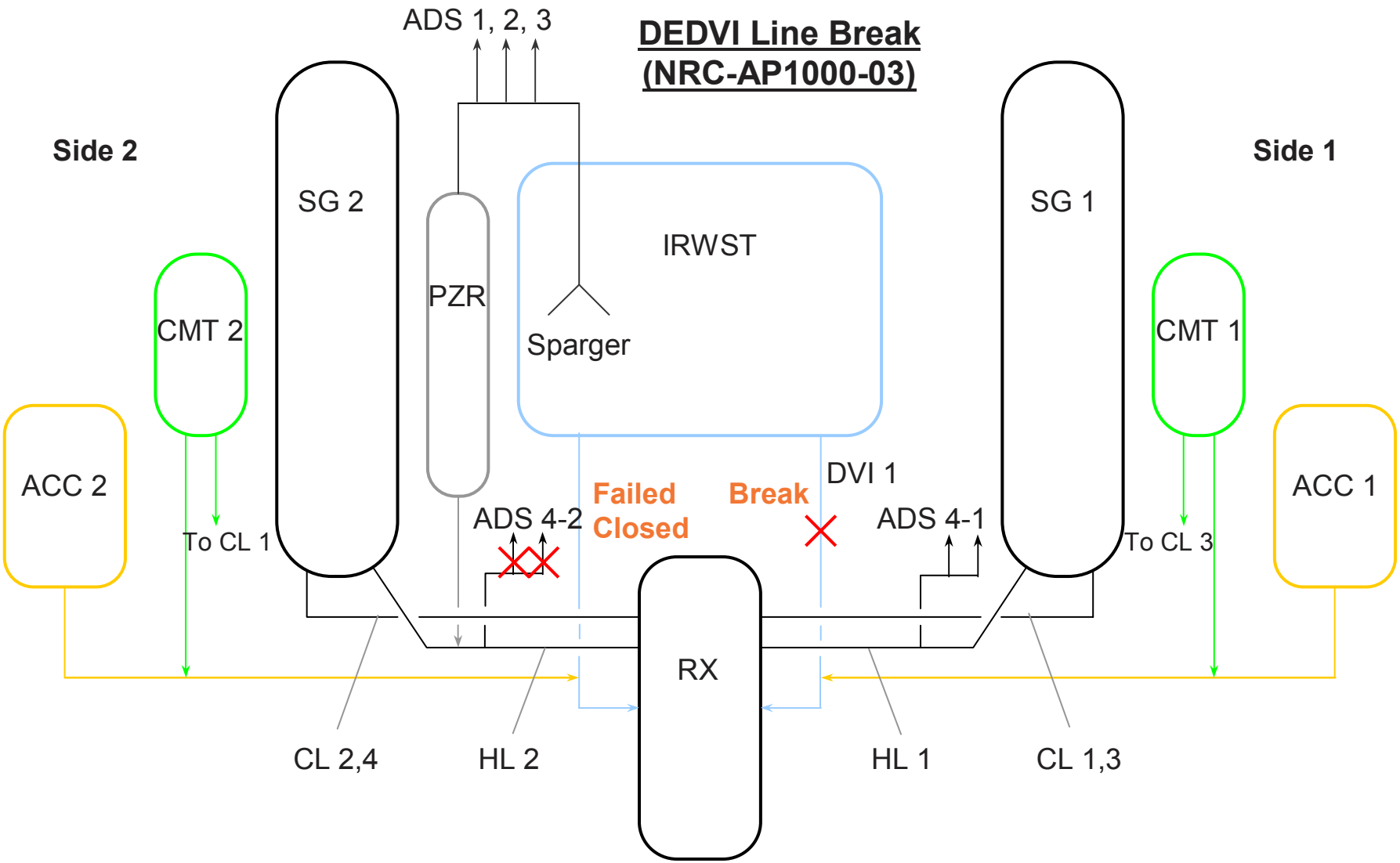
Tests NRC-AP1000-03, 05, 06, and 11

Beyond Design Basis Test Results

- **NRC-AP1000-03**
  - **DEDVI Line Break; Fail Two ADS 4 Valves on PZR Side of Plant**
  - **Plant Went Through All Typical SBLOCA Phases**
  - **Core Remained Adequately Cooled During the Entire Test**



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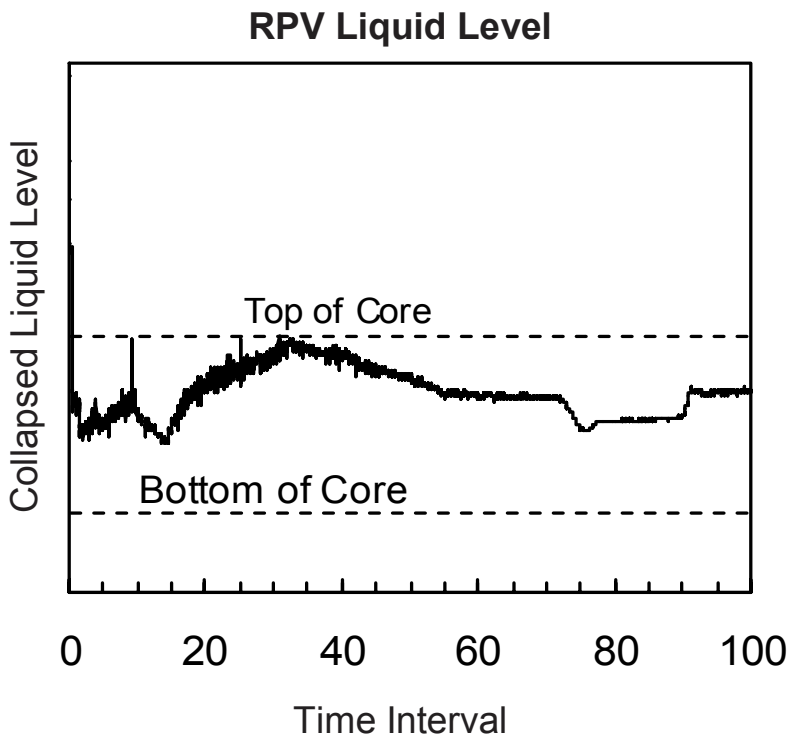
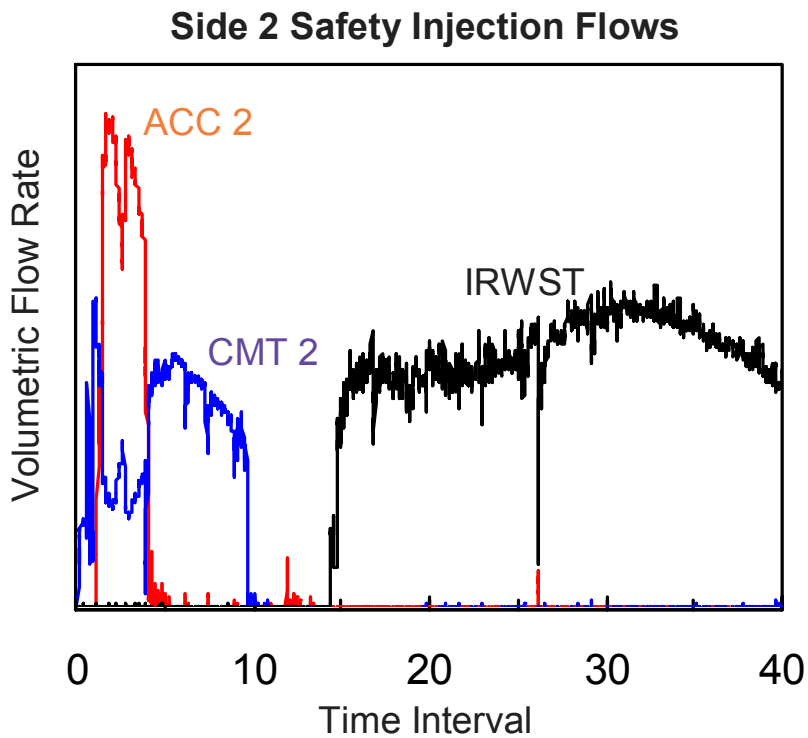
NRC-AP1000-03





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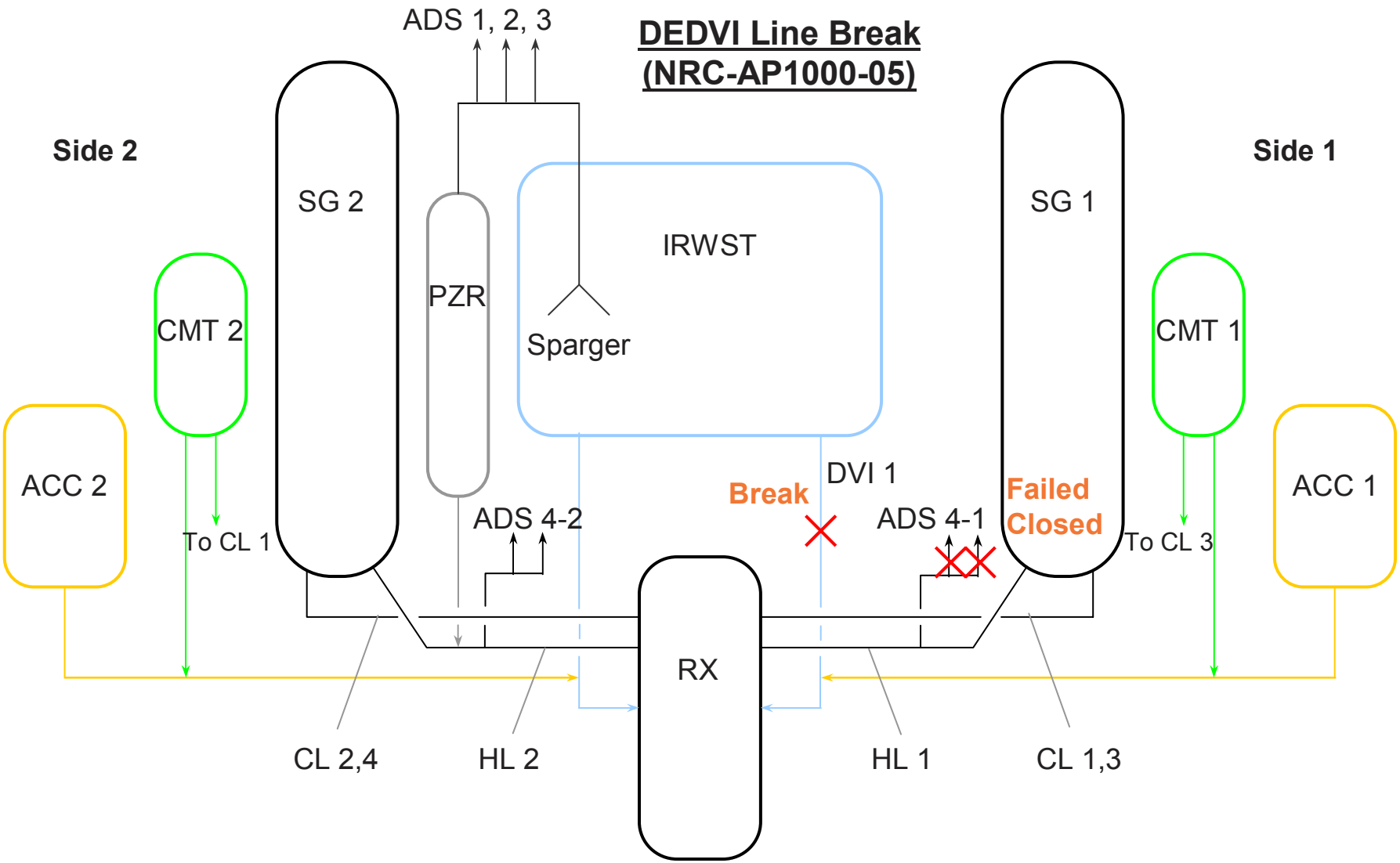
Beyond Design Basis Test Results

- **NRC-AP1000-05**
  - **DEDVI Line Break; Fail Two ADS 4 Valves on Non-PZR Side of Plant**
  - **Plant Went Through First Three Typical SBLOCA Phases**
  - **Core Uncovered Before IRWST Injection Began**
  - **Heater Rods Manually Scrammed**



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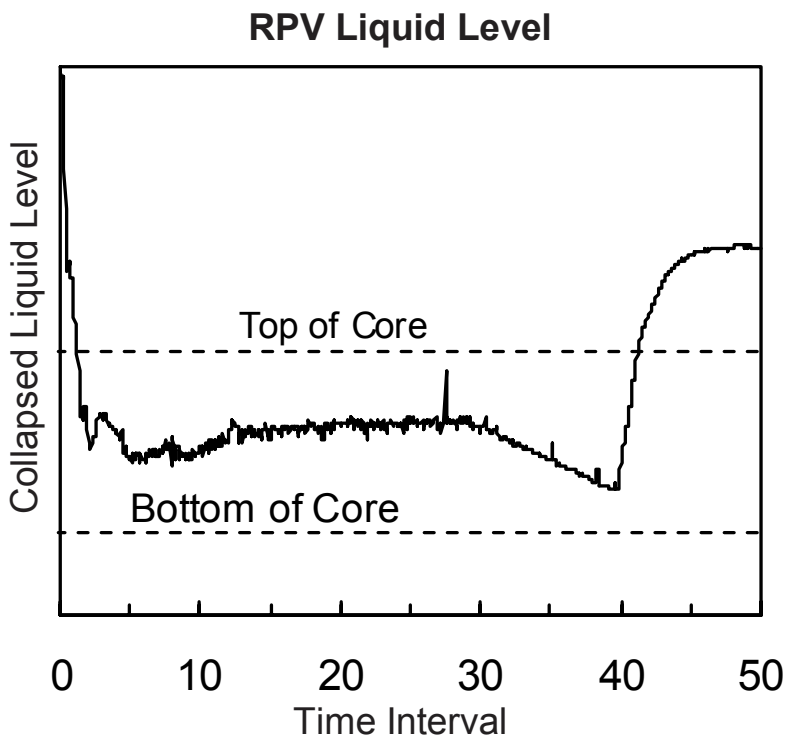
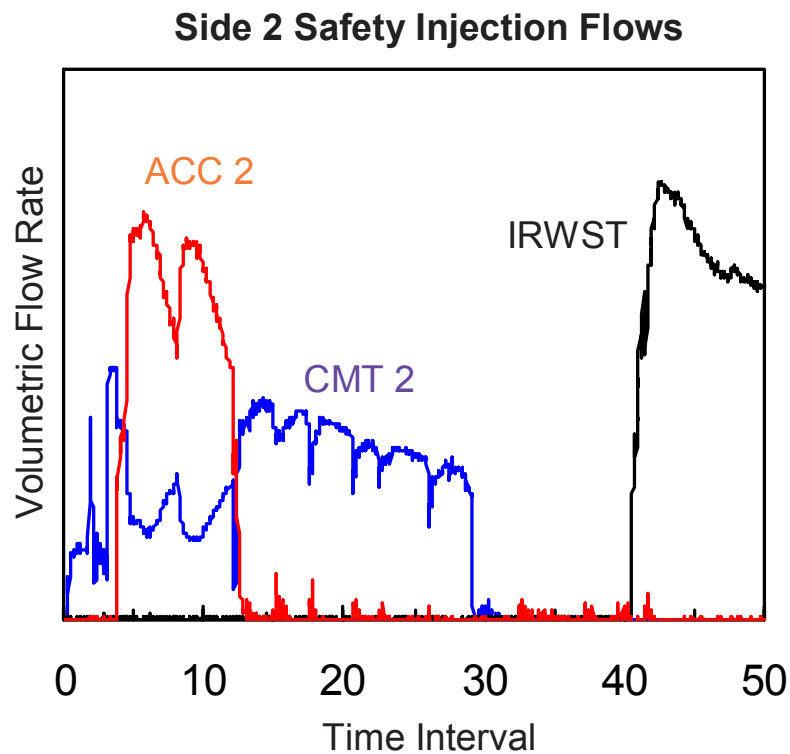
NRC-AP1000-05





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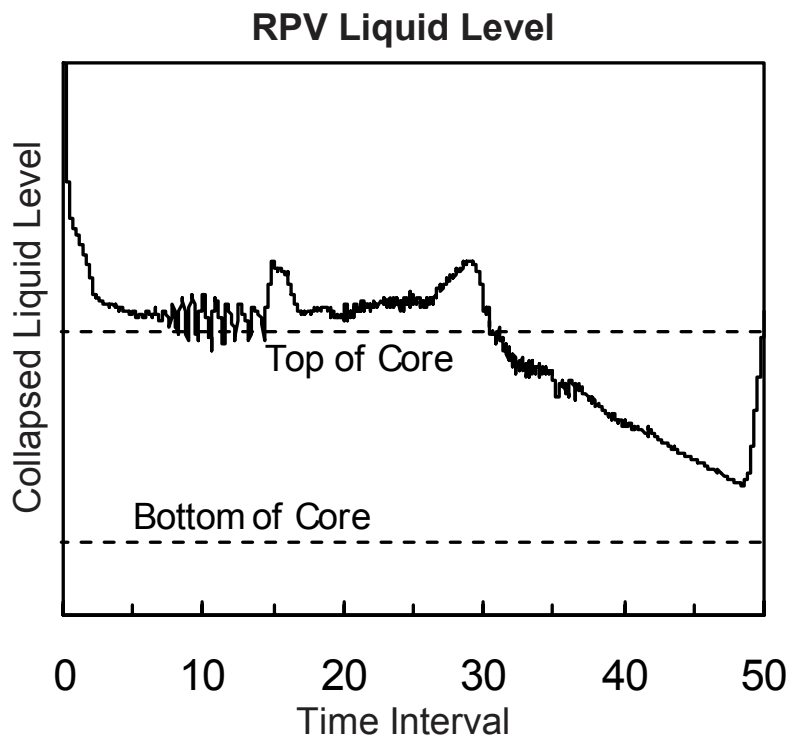
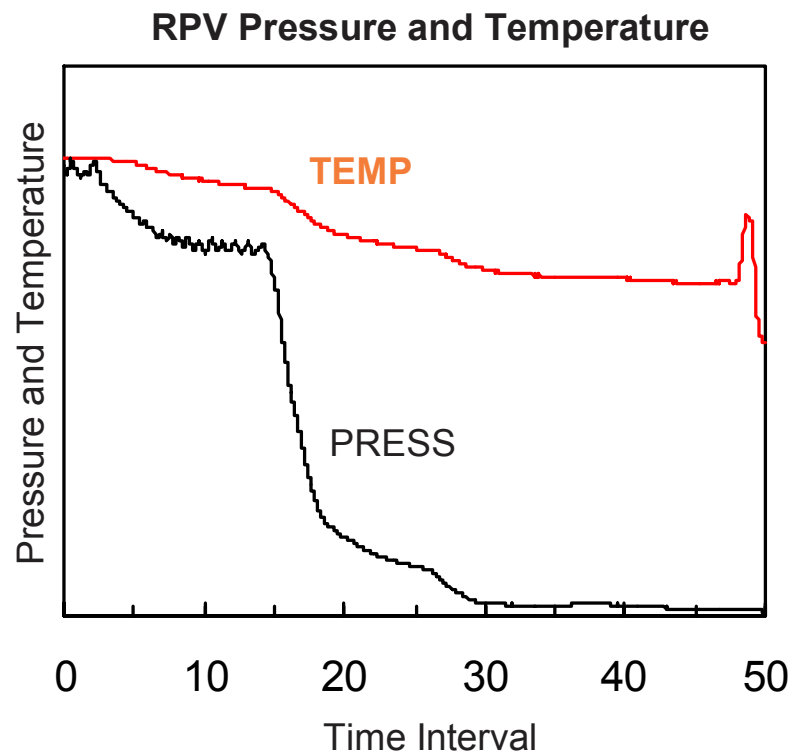
NRC-AP1000-06

- **2-inch (5.04 cm) Cold Leg Break**
  - **Fail two ADS 4 Vales on Non-PZR Side of Plant**
  - **Slower Depressurization Compared to DEDVI Line Break**
  - **Progressed Normally Through ADS Blowdown Phase**
  - **Core Uncovered Before IRWST Injection Began**
  - **Heater Rods Manually Scrammed**

NRC-AP1000-06





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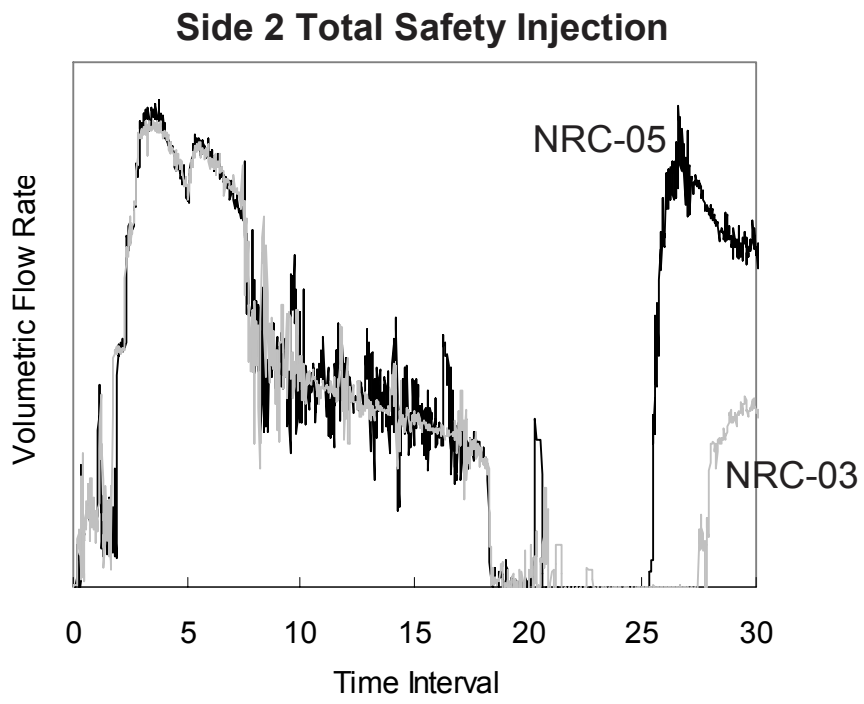
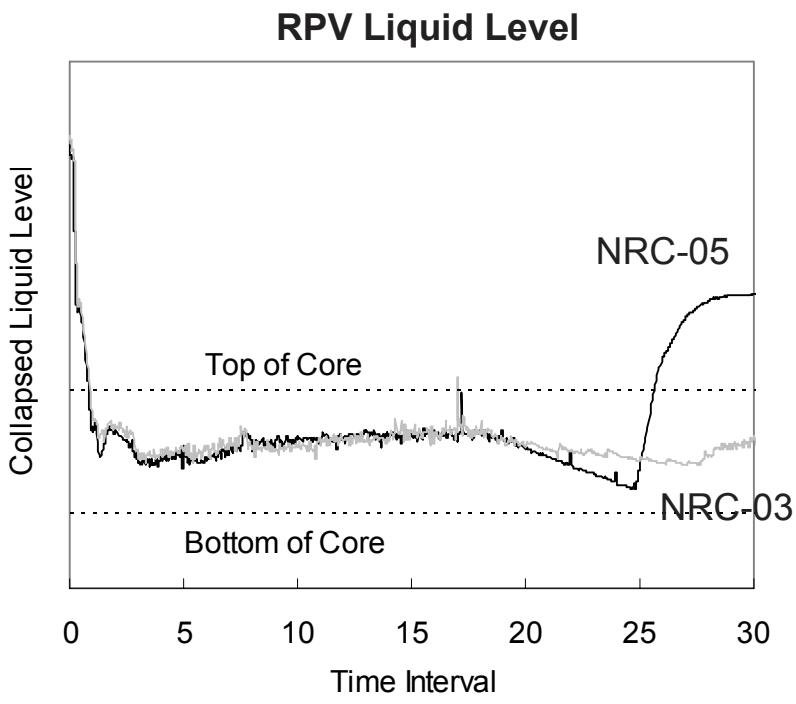
Comparisons

- **NRC-AP1000-03**
  - **DEDVI Line Break with Failure of Two ADS 4 Vales on PZR Side of Plant**
- **NRC-AP1000-05**
  - **DEDVI Line Break with Failure of Two ADS 4 Vales on Non-PZR Side of Plant**

Comparisons





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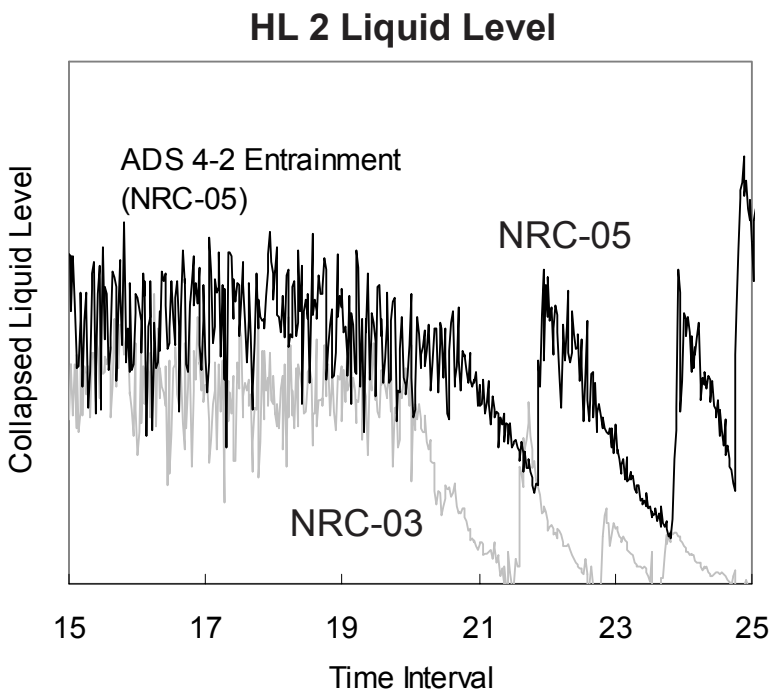

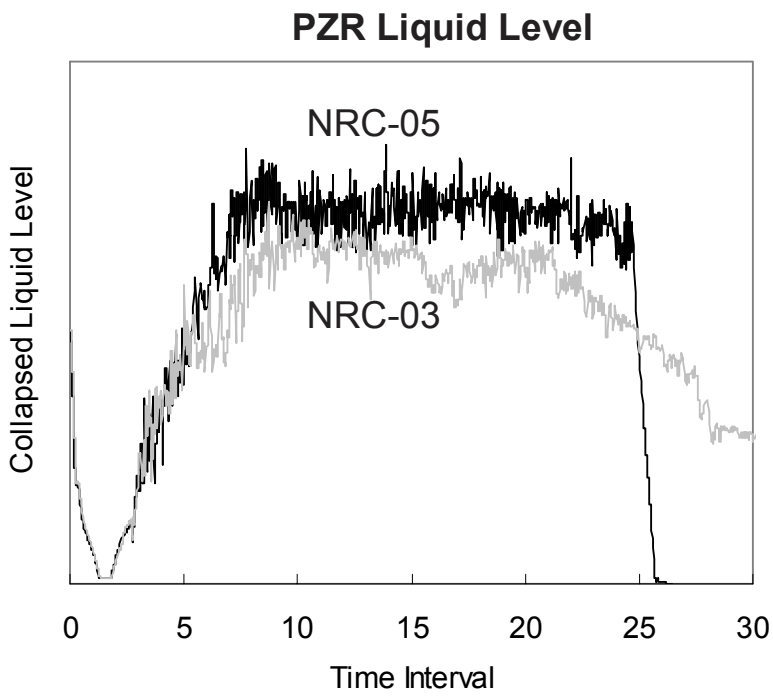

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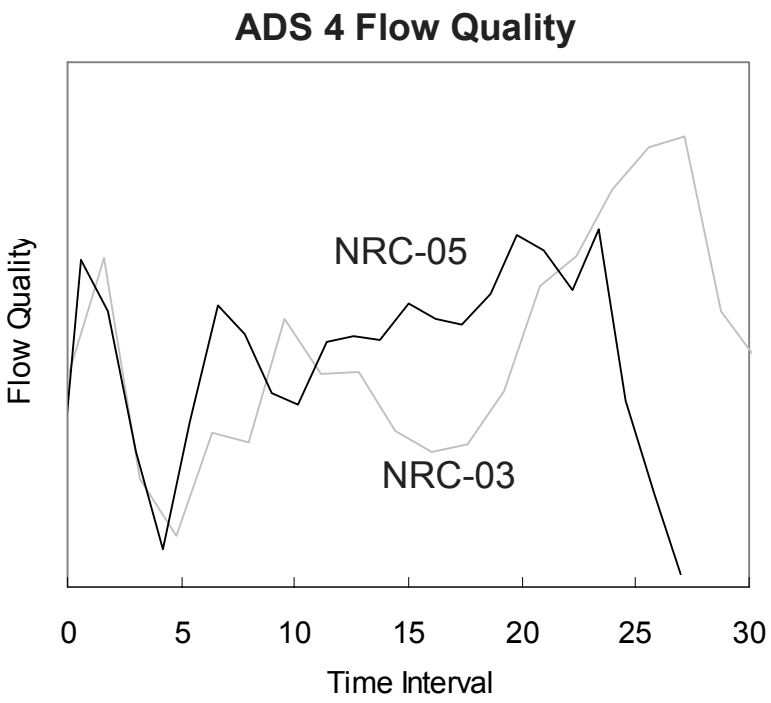

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Comparisons

- High rate of upper plenum entrainment in both tests
- IRWST injection delayed in both tests in part due to conservative facility scaling distortion
- PZR did not drain in beyond design basis test due to present of liquid entrainment out ADS 4-2 line
- Core remained cooled in DBA test

Summary and Conclusions

- **Tests Confirm Significant Liquid Entrainment and Carryover During and After ADS 4 Valve Actuation**
- **Failure of ADS 4 Valves on the Non-PZR Side of the Plant Results in Greater Delay in IRWST Injection Than Failure of ADS 4 Valves on the PZR Side**
- **Failure of Two ADS 4 Valves on the Non-PZR Side of the Plant was Found to Produce Core Uncovery During Simulated DEDVI Line and Cold Leg Breaks**

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Summary and Conclusions

- **No Core Uncovery or Heatup for DBA Tests or for Most of the Beyond-DBA Cases**
- **Test Results were Factored into the Final Evaluation of the AP1000 Design**

Questions ?

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