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U.S. EPR RLBLOCA Topical Report: Round 3 RAI

AREVA NP and the NRC
September 10, 2008

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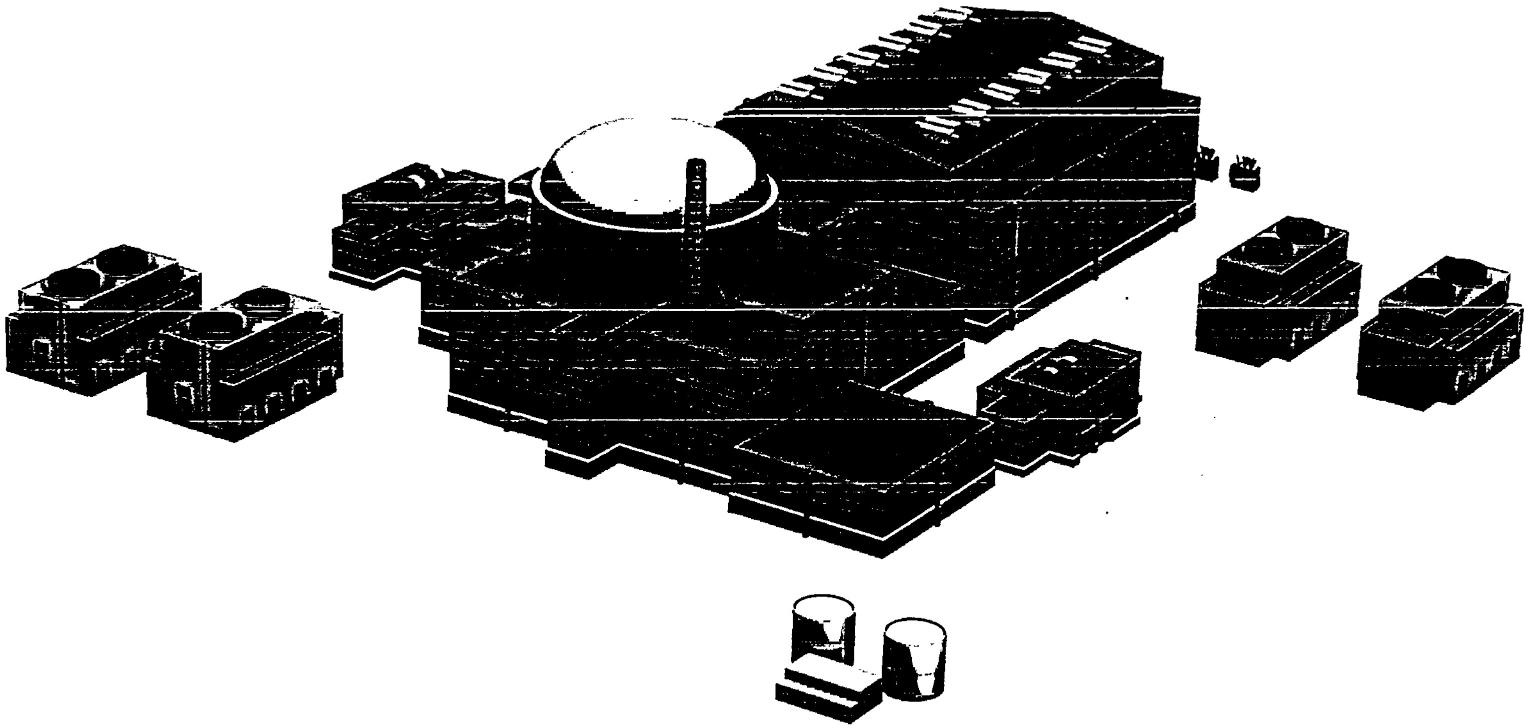
Introduction



Sandra Sloan
Manager, Regulatory Affairs
New Plants Deployment

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Introduction

> Background

> Meeting objectives

- Describe approach to address 3rd Round RAI
- Obtain NRC feedback on proposed approach

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AREVA RLBLOCA History

> EMF-2103 Rev. 0 approved	April 2003
> U.S. EPR RLBLOCA topical report submitted (based on EMF-2103 Rev. 0)	March 2007
> U.S. EPR 1st round RAI issued	July 2007
> Transition program definition	Dec. 2007
> U.S. EPR 2nd round RAI issued	May 2008
> AREVA-NRC meeting to discuss unresolved items	July 2008
> U.S. EPR 3rd round RAI issued	Sept. 2008

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Agenda

- > Introduction – Sandra Sloan
- > Discussion of RAI questions
  - 21 & 29 – Bert Dunn
  - 22 – Bert Dunn
  - 30 – Bert Dunn
  - 31 – Bert Dunn
  - 24 – Eugene Moore
  - 25 – Eugene Moore
  - 26 – Robert Martin
  - 27 & 28 – Robert Martin
  - 34 – Robert Martin
  - 23 – Liliane Schor
  - 32 – Liliane Schor
  - 33 – Liliane Schor
- > Summary and next steps – Sandra Sloan

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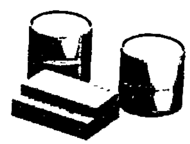
Discussion of RAI Questions: RAI 21 & 29 – Required Case Set for U.S. EPR RLBLOCA Evaluation, & LBLOCA Break Size Range



Bert Dunn
Advisory Engineer, Reactor Operations & Accident Analysis

RAI 21 & 29 – Response

- For the U.S. EPR, AREVA NP will modify the number of case sets run
  - Number of runs in the Case Set = 124
  - Break Spectrum = ANP-10278P = $2xA_{pipe} \rightarrow$ SBLOCA (10% of A_{pipe})
    - Rev. 0 PIRT and modeling designed to cover this break range
    - Transition break range to increase break density near critical size
    - Spectrum change inappropriate for 124 case set
- Separate ordering for PCT, local oxidation, and core oxidation
- Tables of results and cumulative densities reported
- Statement of compliance will be that the cumulative densities demonstrate that these three criteria of 10CFR50.46 are met with a high degree of probability

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Discussion of RAI Questions: RAI 22 – GDC-35 Requirements

RAI 22 – Response

> For the U.S. EPR, by design, there is no significant difference in results between the LOOP and non-LOOP case

- ECCS set to minimum either way
- Automatic pump trip on coincident SI signal and low RCP differential pressure (detecting void fraction)
- ECCS delays for non-LOOP condition < LOOP condition

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Discussion of RAI Questions: RAI 30 – Forslund-Rohsenow Heat Transfer Correlation

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RAI 30 – Response

> This issue has been addressed in the transition package as presented in ANP-2695, "Sequoyah Nuclear Plant Unit 1 Realistic Large Break LOCA Analysis," February 2008

> An S-RELAP5 code modification limits the amount of Forslund-Rohsenow heat transfer correlation's contribution to the film boiling heat transfer calculation to no more than 15% for void fractions above 90%

> This is the approach that will be taken for the U.S. EPR RLBLOCA analysis

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Discussion of RAI Questions:
RAI 31 – Downcomer Boiling

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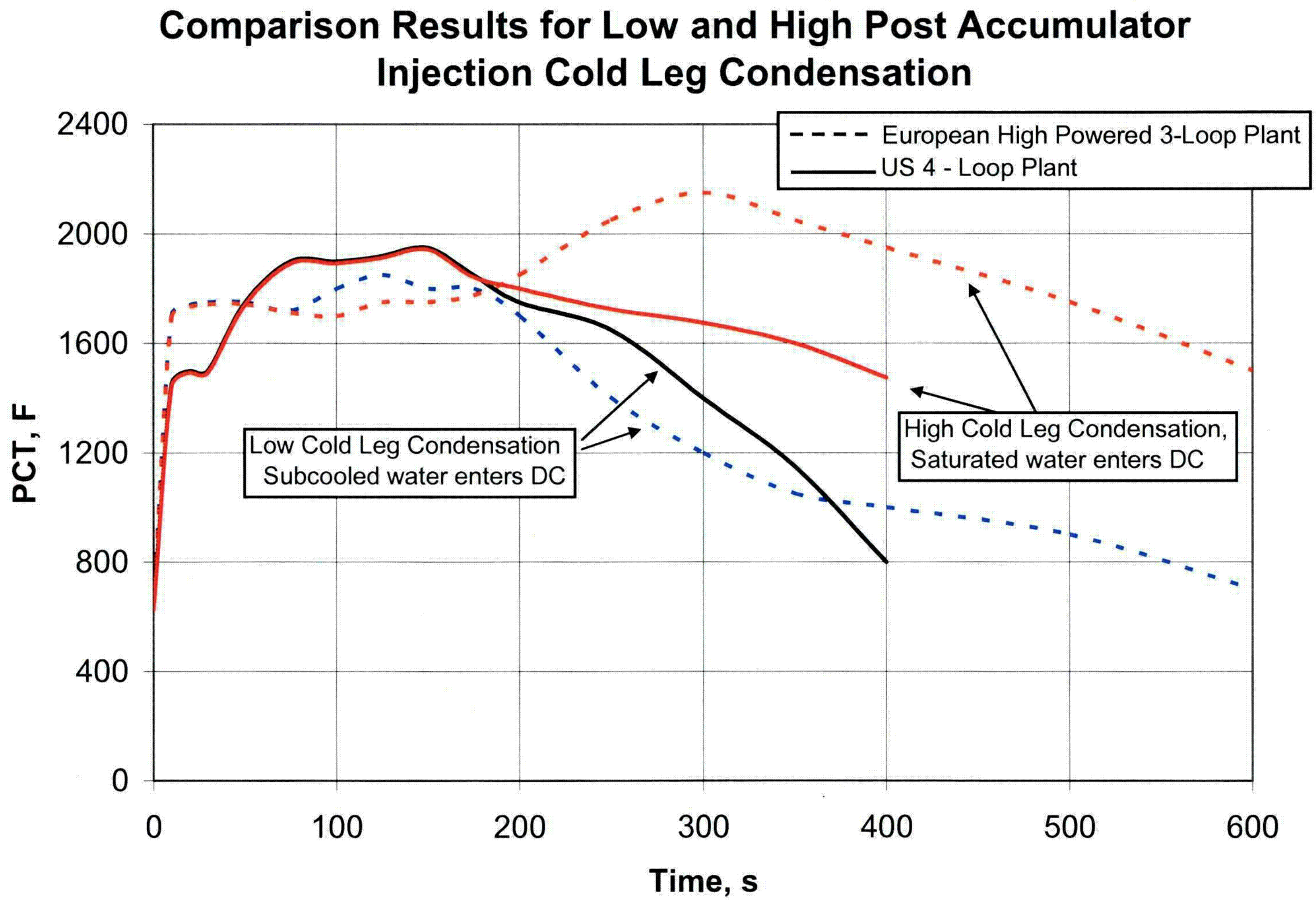
RAI 31 – Response

> Downcomer boiling issue
  - Transition package demonstrations
    - Wall heat release
    - Axial noding sensitivity
    - Azimuthal noding sensitivity
    - Cold leg condensation rates

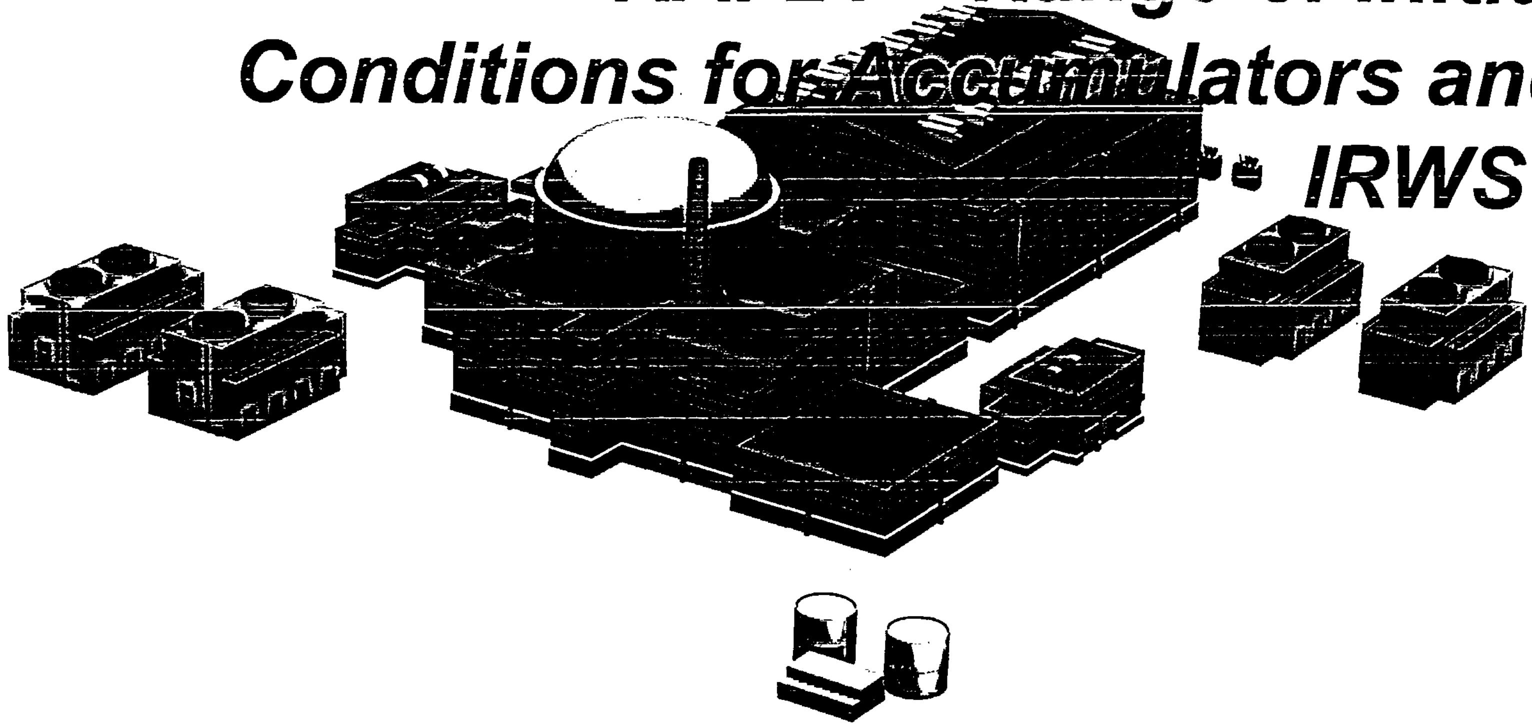
> Cold leg condensation is important to the prediction of downcomer boiling phenomena and will be modeled in a new case set

> AREVA NP will document transition package sensitivity studies in revised ANP-10278P

RAI 31 - Cold Leg Condensation Effect



Discussion of RAI Questions: RAI 24 – Range of Initial Conditions for Accumulators and IRWST



Eugene Moore
Safety Analysis Group

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RAI 24 – Response

- Provide detailed justification for the source of initial pressure, temperature, and volume of accumulators and IRWST
- Response will relate to technical specifications and explain relationship between building locations environment and the technical specification values

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RAI 24 – Example
Building Ambient Conditions

	Temperature, °F	
	Lower	Upper
Analysis Values (Acc., IRWST, Bldg.)	59	122
Technical Specification Values		
Building	59	131
IRWST	59	122
Accumulator Compartment	59	86
Maximum Expected Equipment Compartment Temperatures		
Below 2.3 m (see Note)		86
Between 2.3 - 10 m		104
Between 10 - 18 m		122
Above 18 m		131
Average		122

Note:

Top of IRWST equipment compartment at 0.0 m

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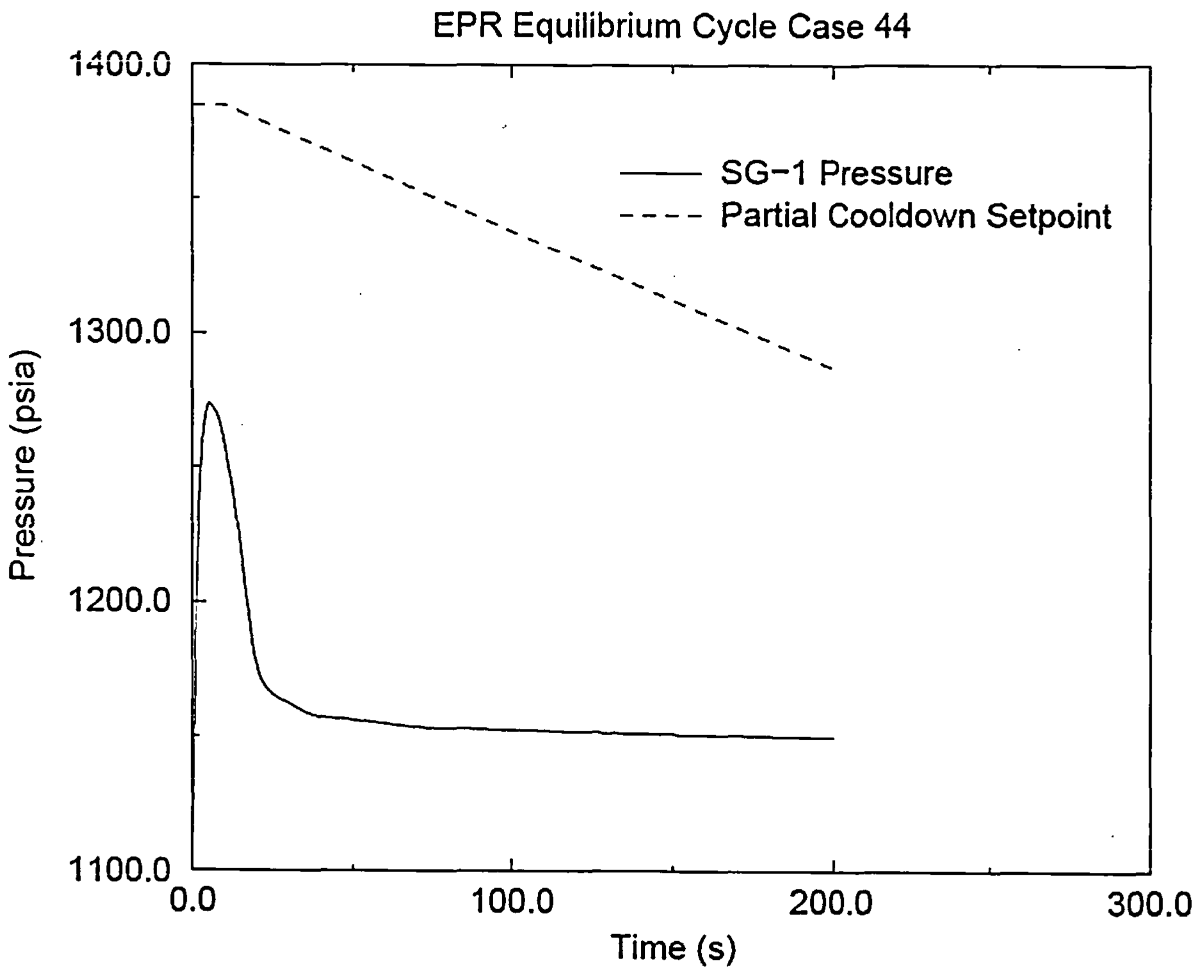
Discussion of RAI Questions: RAI 25 – MSRT Partial Cooldown

RAI 25 – Response

- Document rationale for approach
  - Steam generator is instantaneously isolated at the time of the break
  - The secondary side relief or safety valves not modelled because they are not actuated for limiting breaks
  - Automatic steam generator partial cooldown to 870 psia (setpoint reached only for break sizes of 1.5 ft^2 or less, 15% DEGB)
  - No depressurization for these smaller breaks is conservative
  - Refill of loop seals will only occur at extended times and for pressures much below lowest steam generator pressures
- Sensitivity studies

RAI 25 – Sensitivity Study Example Maximum PCT Case (65% DEGB)



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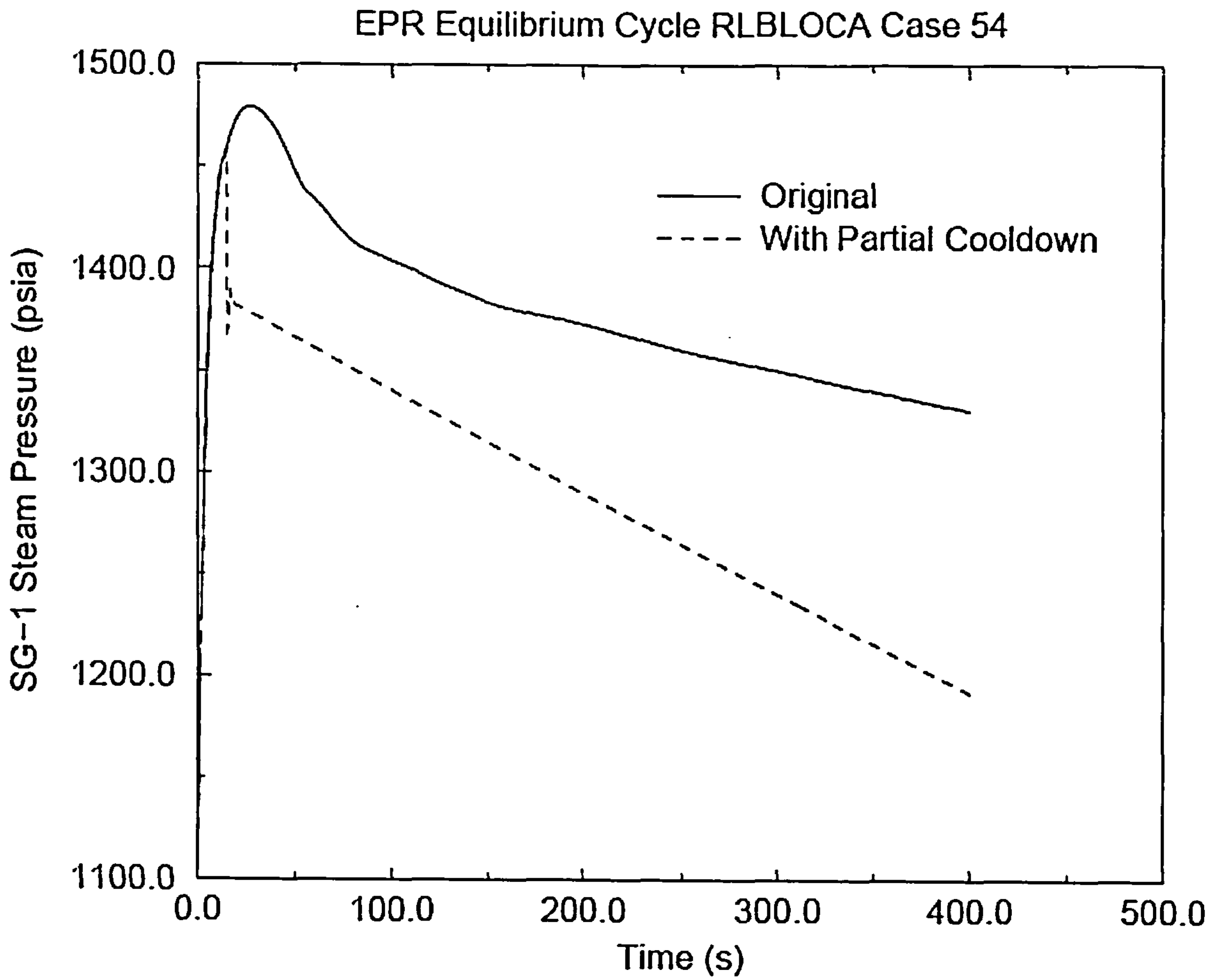
RAI 25 – Sensitivity Study Example (10% DEGB)



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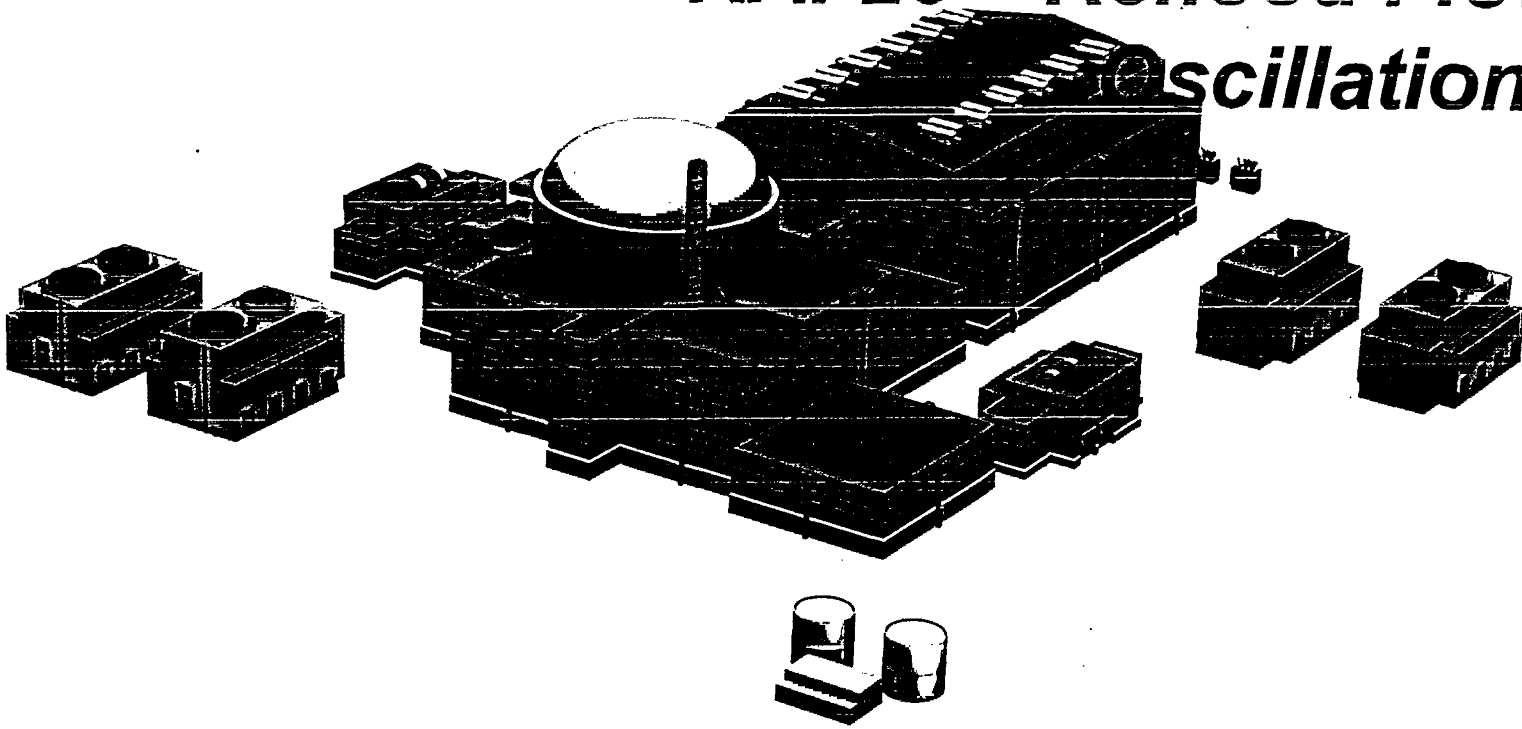
Discussion of RAI Questions: RAI 26 – Reflood Flow Oscillations



Robert Martin
Advisory Engineer, Severe Accidents

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RAI 26 - Response

> Flow oscillations question to be resolved by building on the technical basis of EMF-2103(P)(A):
  - Describe the particular oscillatory phenomena of interest, distinguish between cold-leg accumulator, manometer, and loop SI driven
  - Identify the analytical and experimental basis
  - Revisit earlier code-to-data comparisons drawn from existing code assessments (EMF-2102) to address code performance in general and at different scales

> Additional sensitivity analysis will examine the influence of various phenomenological contributors on the magnitude of oscillations and clad temperature, including
  - Accumulator/SI temperature
  - Interfacial heat transfer (condensation) – increase in condensation applied for RAI 31 are expected to reduce any clad temperature sensitivity to oscillations
  - Others, as necessary; however, modification of core inlet resistances is not phenomenologically based; thus, not an appropriate study

> Assess sensitivity with appropriate measures (i.e., clad temperature, liquid level, and mass flux)

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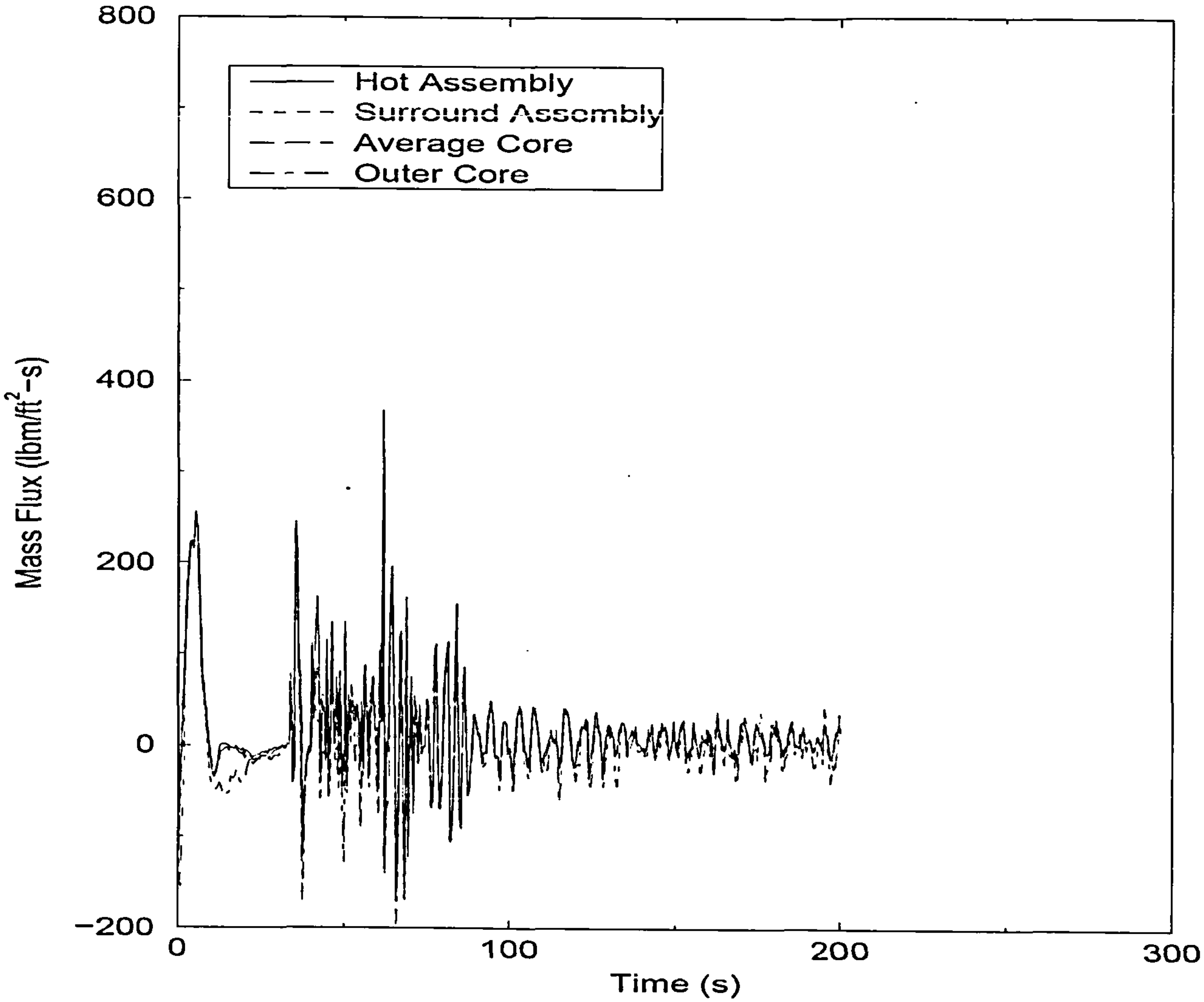
RAI 26 – U.S. EPR RLBLOCA

Topical Report Figure A-13, Core Inlet Mass Flux



Discussion of RAI Questions: RAI 27 & 28 – System Pressure Spike on Accumulator Discharge

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RAI 27 & 28 – Response

- Both RAIs are related to post-cover-gas-release transport phenomena (i.e., pressure and clad temperature sensitivity).

  A technical basis will be built from:
  - Description of the phenomena, decomposed by important process and/or phenomenological contributors
  - Consolidating original technical basis presented in methodology document (EMF-2103) and developmental assessment document (EMF-2102)
  - Experiment insights from ISP-25, Achilles; investigate other programs for additional validation, where applicable
  - Analytical trends from previous RLBLOCA analyses
- Sensitivity analysis will examine the influence of various phenomenological contributors on the magnitude of pressure increase as the accumulator cover gas escapes the RCS and on clad temperature
  - Accumulator size (cover gas volume)
  - Interfacial heat transfer
  - Others (e.g., break modeling, steaming rates)

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Discussion of RAI Questions: RAI 28 – Achilles Reflood Cooling Comparison

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RAI 28 – Response

> The question of accumulator cover-gas impact on LBLOCA analyses was addressed during the development EMF-2103 Rev. 0.

> Address this RAI by:

- Description of the phenomena, decomposed by important process and/or phenomenological contributors
- Consolidating original technical basis presented in methodology document (EMF-2103) and developmental assessment document (EMF-2102)
- Complement with other available test program results reported in EMF-2102, where applicable

Discussion of RAI Questions: RAI 34 – Limiting Time in Life for LOCA Analyses

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RAI 34 – Response

> The questions on burn-up dependencies (stored energy, rupture) on LBLOCA analyses was addressed during the development of EMF-2103 Rev. 0.

> Address this RAI by:

- Description of the phenomena, decomposed by important process and/or phenomenological contributors
- Consolidating original technical basis presented in methodology document (EMF-2103)
- Compare system parameters from earlier analyses to U.S. EPR to disposition application to the U.S. EPR

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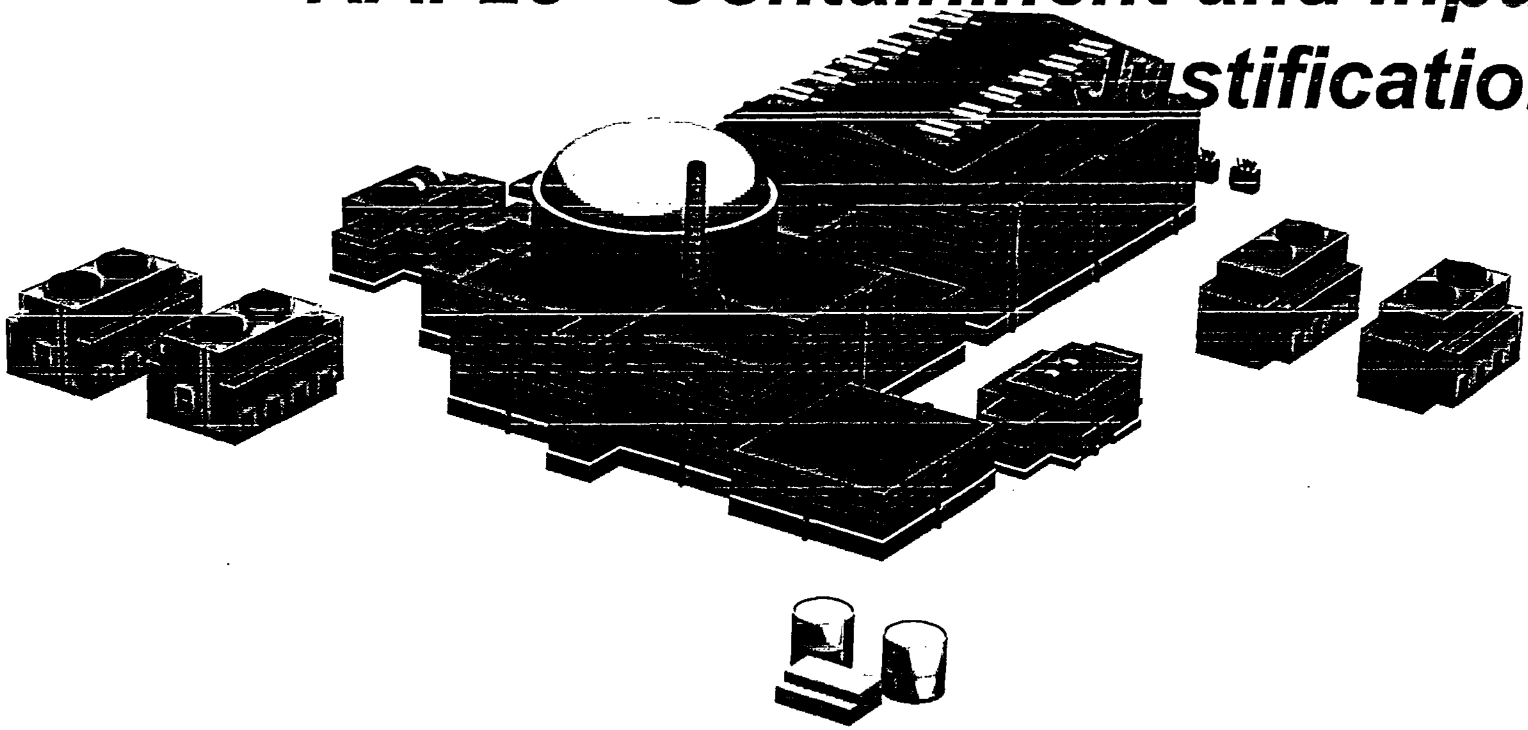
Discussion of RAI Questions: RAI 23 – Containment and Input Justification



Liliane Schor
Supervisor, LOCA Group

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RAI 23 – Response

- Basic approach will be similar to that of the transition program
- ICECON topical, EMF-CC-039, will be provided
- Inputs and modeling options for ICECON will be justified consistent with the transition program

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RAI 23 – Examples from Containment Analysis

- Heat structures modeled conservatively
- Heat sink surface area increased by 10%
- Paint modeled as substrate
- No air gap to liner
- Free volume sampled from expected to large limit (lower transient pressure response)
- Containment temperature sampled over technical specification range
- Humidity set to 1.0
- Condensing heat transfer coefficient (1.7 Uchida, transition program)
- Spilled ECCS mixed with containment atmosphere

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Discussion of RAI Questions: RAI 32 – Rod-to-Rod Radiation

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RAI 32 – Response

> The transition program addressed this issue by comparison of expected plant radiation heat transfer to radiation heat transfer in the FLECHT-SEASET benchmarks

- Rod-to-rod radiation increases above that subtended in the convective heat transfer modeling as cladding temperature approaches limiting values (>1700 F)
- Current treatment is conservative at limiting PCTs

> RAI response will provide justification consistent with the transition program

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Discussion of RAI Questions:
RAI 33 – Decay Heat

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RAI 33 – Response

> Provide justification for EMF-2103 Rev. 0 method

> In accordance with Regulatory Guide 1.157, calculate the decay heat based on the 1979 ANSI/ANS standard

> The standard is applied conservatively

- Infinite operating time at full power
- All fissions assumed from U-235

> Uncertainty sampling base - 1979 ANSI/ANS standard

- Gaussian distribution
  - Mean = 1.0
  - Standard deviation = 3%

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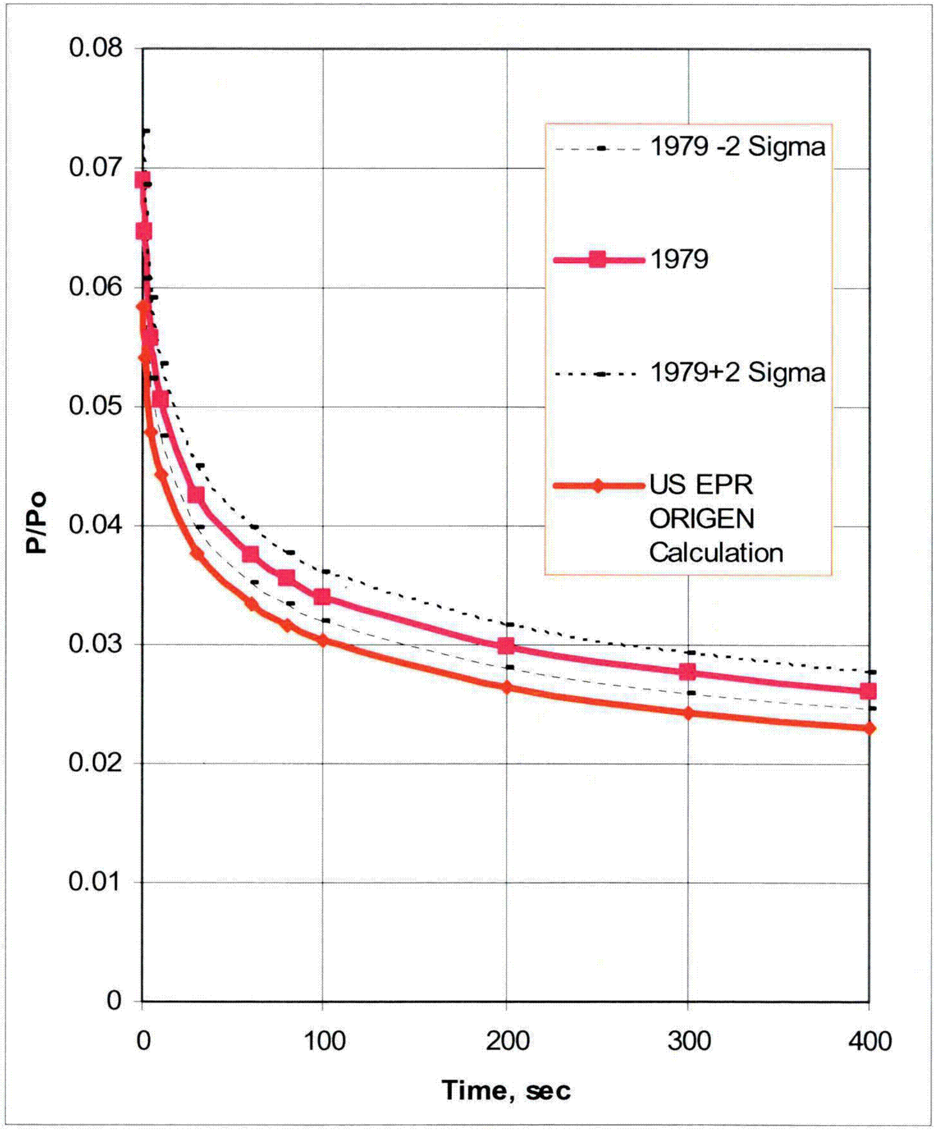
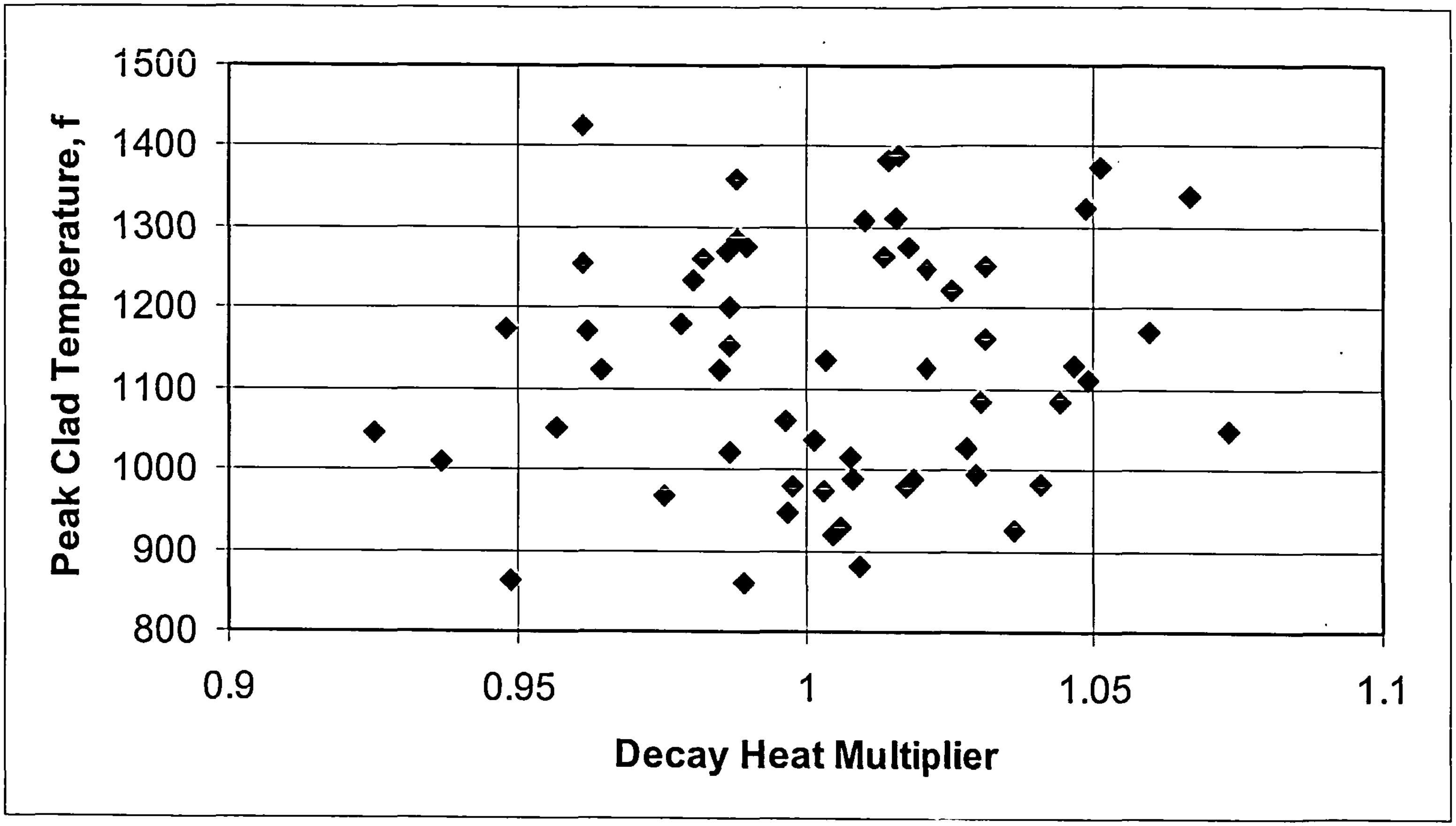
RAI 33 – Comparison 1979 ± 2σ with ORIGEN-2



RAI 33 – PCT vs. Decay Heat Ratio (Equilibrium Cycle)



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RAI 33 – Response Conclusion

> For this equilibrium cycle calculation set, the limiting case is a blowdown peak, which minimizes the importance of decay heat (sampled multiplier ~ 0.96)

> The decay heat sampled values range from ~ -2.5 to +2.5 σ

> The 2nd, 3rd, and 4th cases sample above 1.0

> For other calculational sets the limiting PCT could occur for multiplier > 1.0

- The first core calculational set has a multiplier of ~ 1.05 for the limiting PCT case

> The current approach to decay heat is consistent with CSAU and Regulatory Guide 1.157

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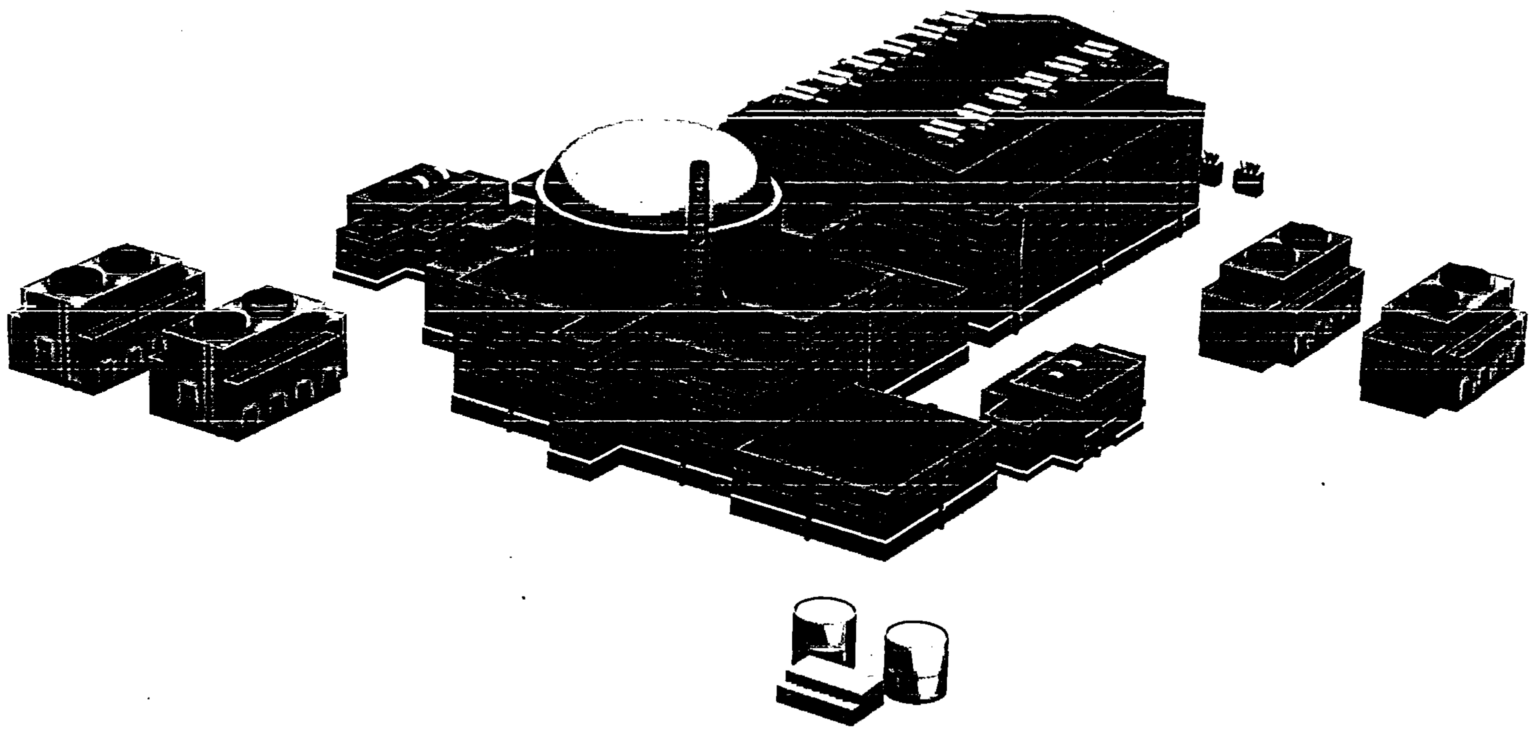
Summary and Next Steps



Sandra Sloan

Summary and Next Steps

> Resolution strategy identified for each RAI question

> AREVA to address 3rd round RAIs as described

> AREVA to keep NRC apprised of progress and identify appropriate opportunities for future meetings

> AREVA to provide:

- RAI responses
- Topical Report revision
- FSAR markups (as appropriate)