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# Fundamental Issues for Consequence Analysis

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# Presentation Outline

1. Is the plant modeled correctly?
2. Are the sequences sufficiently well defined?
3. Are the controlling phenomena well defined?
4. Are there experimental technical bases for the controlling phenomena?

# Is the Plant Modeled Correctly

- BWR RCS Type
  - External Recirc Pumps
  - Internal Recirc Pumps
- BWR Containment Type
  - Mark I
  - Mark II
  - Mark III
- PWR RCS Type
  - How many loops (Westinghouse)
  - CE
  - B&W
- PWR Containment Type
  - Large dry
  - Subatmospheric
  - Ice condenser

# Are the Sequences Sufficiently Well Defined?

- Are the EOPs included?
- Are the SAMGs included?
- Is ECCS injection involved?
- Are accumulator discharges involved?
- Does the sequence progress to RPV failure?

All of these influence the mass of hydrogen generated both in-vessel and ex-vessel.

# Importance of the First Two Points

- Points 1 and 2 essentially determine the frequency of core damage and thus one important controlling aspect of consequence analyses.
- Also these first two considerations essentially determine the extent of hydrogen formed and the timing of its release to the containment. This is also an essential part of the consequence evaluations.

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# Are the Controlling Phenomena Well Defined?

(Note: This is plant specific.)

- Fission product release, transport and deposition.
- Core damage progression and the resulting temperature and pressure history in the RCS.
  - RCS natural circulation.
  - Material creep.
  - Fission product deposition and revaporization.
- Fission product removal by steam condensation including containment sprays.
- RPV failure modes.
- External cooling of the RPV lower head.
- Scrubbing in water pools.
- Containment failure modes.

# Example of Well Defined Controlling Phenomena

- Consider a PWR with inverted U-tube steam generators.
- Core damage at an elevated system pressure causes natural circulation flows to be established
  - core-to-upper plenum,
  - upper plenum to SG inlet plenum,
  - out flow and return flow through the SG tubes.
- Analyses have suggested that these flows could challenge the integrity of some SG tubes.

# State-Of-The-Art

- SG out flow and return flow has an extensive experimental basis (can be a steady-state process).
- Upper plenum to SG inlet plenum has a significant experimental basis (can be quasi-steady state process).
- Core-to-upper plenum has a limited experimental basis, is a dynamic process (continually changing geometry) and to date has not been reconciled with the TMI-2 upper plenum temperature, i.e. temperatures are much lower than calculated by computer codes.

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# State-Of-The-Art (Continued)

Question: Are the controlling processes for assessing thermal challenges to the SG tubes well defined?

Comment: This sequence can have a substantial influence on consequence evaluations.

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# Conclusion

- When performing consequence evaluations, the results need to be clear on:
  - Plant specific capabilities.
  - Need to include EOPs and SAMGs.
  - Technical bases for the influence of plant specific capabilities.
  - State-of-the-art
    - Uncertainties: Tend to lean more on the conservative side without sound technical reasons.
- Documentation needs to communicate all of these aspects.