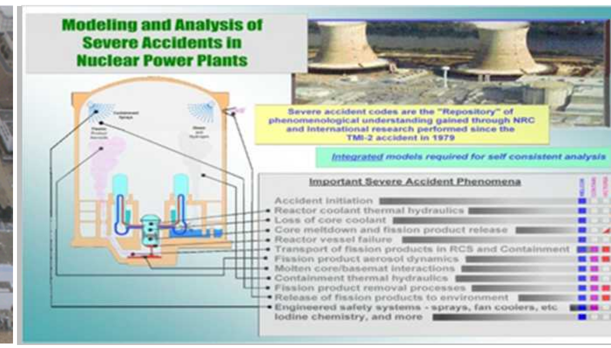
SAND2014-20562PE

Exceptional service in the national interest

Sandia National Laboratories

Used by permission from TEPCO


Used by permission from TEPCO



MAAP-MELCOR "Crosswalk" Phase 1 Review and Progress Update

Don Kalinich, Sandia National Laboratories
David Luxat, ERIN Engineering

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Topics for discussion

- Review of…
  - work scope
  - FY13 work
- Update on FY14 work
- Sequence Summary Results
- Summary of key results
  - preliminary conclusions
  - limited set of comparison plots
- Future Work

Work Scope

- Compare MAAP and MELCOR results to identify areas where the codes differ in their treatment of accident phenomena
  - Use Fukushima Daiichi Unit 1 (1F1) models to create results for comparison
  - Focus on core melt progression
  - Use comparison of results to identify where phenomena are treated/modeled differently

FY13 Work

- MAAP and MELCOR 1F1 results were presented in October 2013
- It was identified that the models and accident sequences were not consistent
  - IC operation, FW coastdown, water and component inventories
  - SRV failure vice MSL failure
- Differences in the models and codes result in differences outputs between the codes, making comparisons difficult
- Regardless, preliminary differences were identified
  - In MELCOR, debris cannot completely block a core flowpath; MAAP can completely block a core flowpath
  - MAAP calculates the formation of an in-core molten pool over top a crust, with the molten pool eventually failing into the downcomer/jet pumps; MELCOR calculates solid debris relocating to the lower core plate; eventually failing the plate and allowing debris then relocate into the lower plenum

FY14 Work

- Updated models to reflect latest NEA plant data and BSAF boundary conditions.
- Modified models to minimize water and component inventory differences
- Ran models with a common accident sequence
  - IC operation, FW coastdown, decay heat
  - Turned off MSL failure in MELCOR model; forced SRV failure (stuck-open) at 7 hr in both models
- Developed a set of common results figures
- Documented latest results, comparison, conclusions, and recommendations for Phase 2 work in an EPRI report

Sequence Summary Results

- MAAP calculates core degrades to form a crust with an overlying molten pool within the active core region. The crust/molten pool completely block axial flow through the core. Eventually the molten pool melts through the core shroud, allowing molten material to relocate to the lower plenum via the downcomer/jet pumps. Relocated material forms crust with an overlying molten pool within the lower plenum.
- MELCOR calculates the core degrades mainly in the form of solid particulate debris that relocates to the lower core plate. Some small fraction of molten material relocates into the lower plenum before lower core plate failure. Axial flow through the core is never completely blocked by debris. Once the lower core plate fails, debris relocates into the lower plenum. Degradation and failure of the control rod guide tubes results in further fuel failures. The majority of the relocated material remains solid particulate debris.

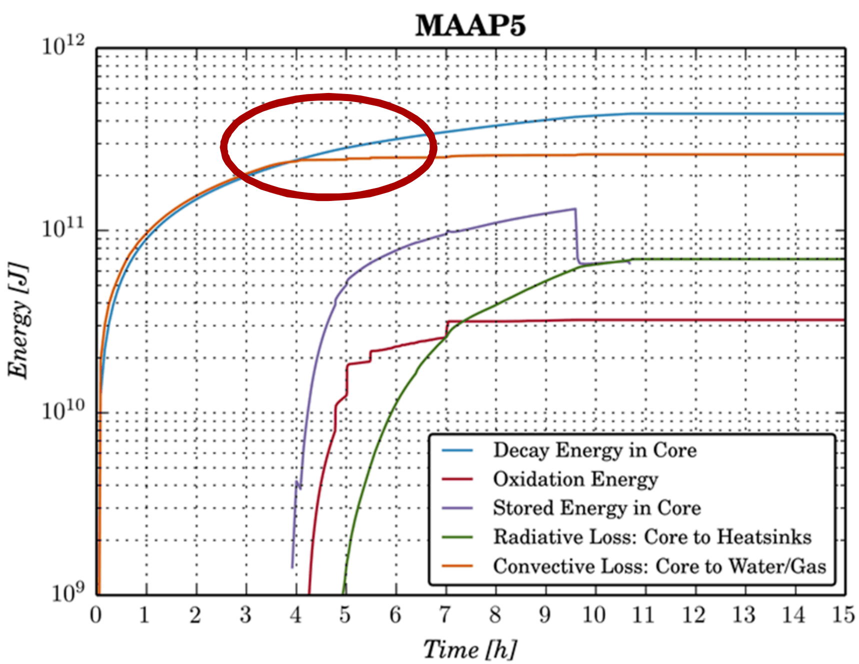
Summary of Key Results

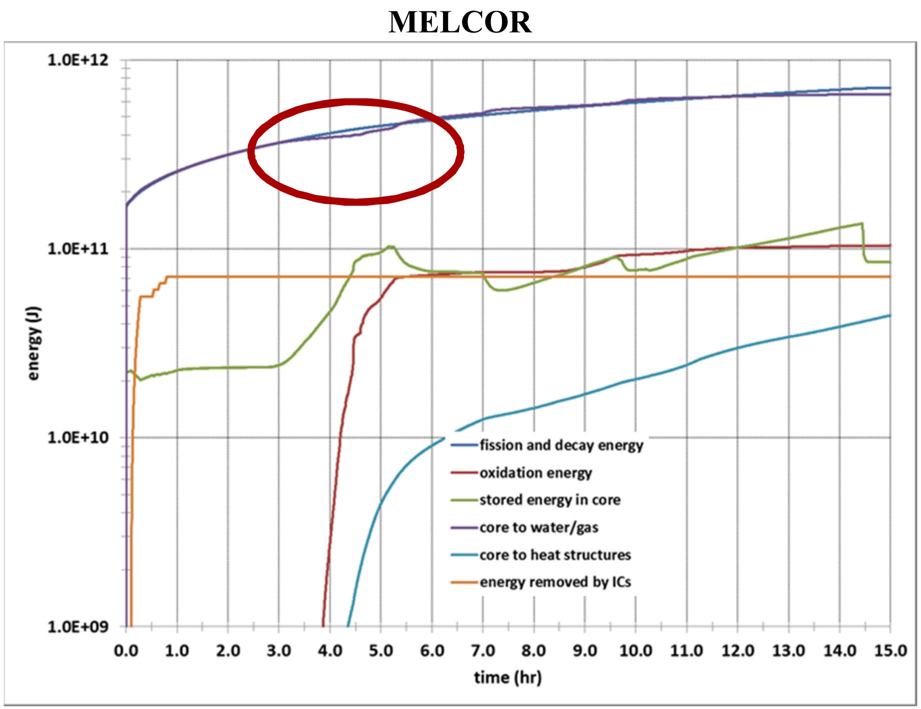
- Differences in code physics models and inputs, along with a paucity of plant data, makes creating “apples-to-apples” plant models and outputs for comparison difficult
- Up to the point of core degradation the code results match relatively well. Difference seen in boil down is due the partitioning of water between RPV volumes in the two codes
- MAAP predicts complete blockage of axial flowpaths; MELCOR has a minimum porosity (code default = 5%)
- MELCOR calculates a much larger amount of energy transferred from core materials to RPV water/gases than MAAP
- MAAP models the heat transfer (area and hx-fer coef.) from particulate debris as decreasing with decreasing debris bed porosity; MELCOR models heat transfer surface area as increasing with the volume of particulate as its effective hydraulic diameter does not vary with porosity

Summary of Key Results

- MAAP does not model radial relocation of particulate debris; MELCOR models radial relocation of particulate debris as a "leveling" effect with a user-defined time constant
- MAAP has an a priori assumption for the lower plenum debris bed; MELCOR performs a series of calculations to determine how debris moves (over the lower plenum spatial nodalization) to form the lower plenum debris bed

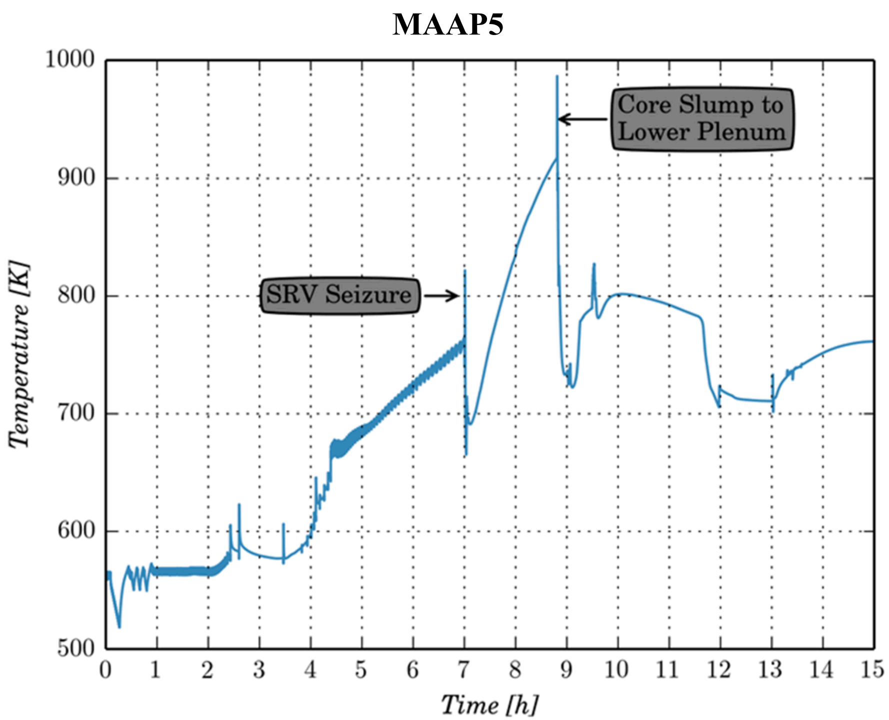
System Energy Balance

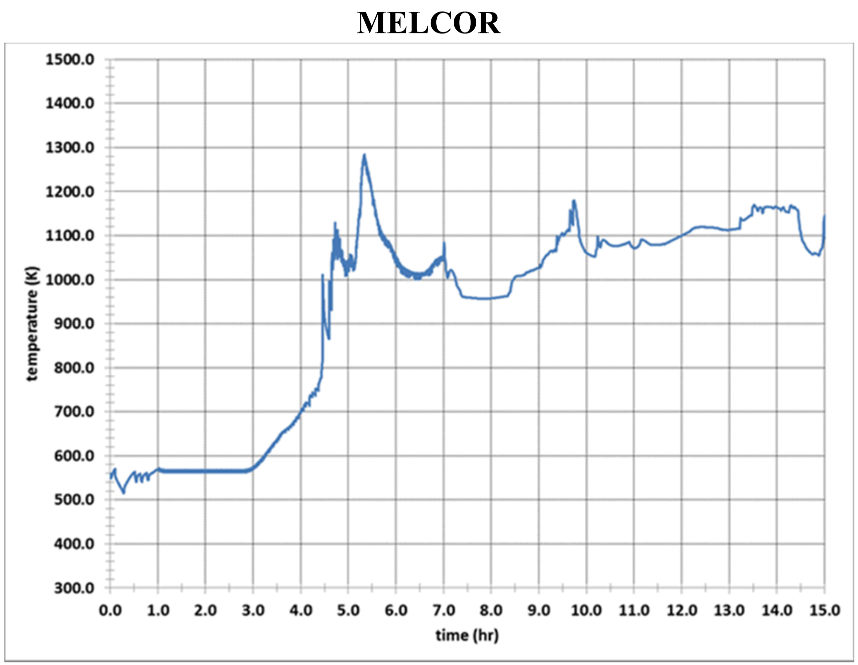




- MELCOR rejects more energy from the core materials than does MAAP5

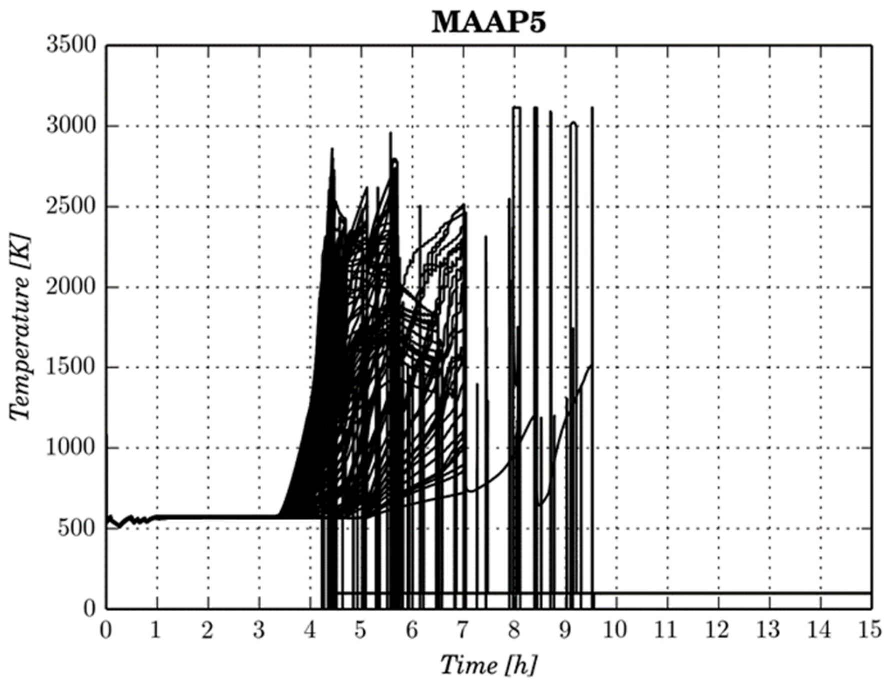
Steam Dome Temperature

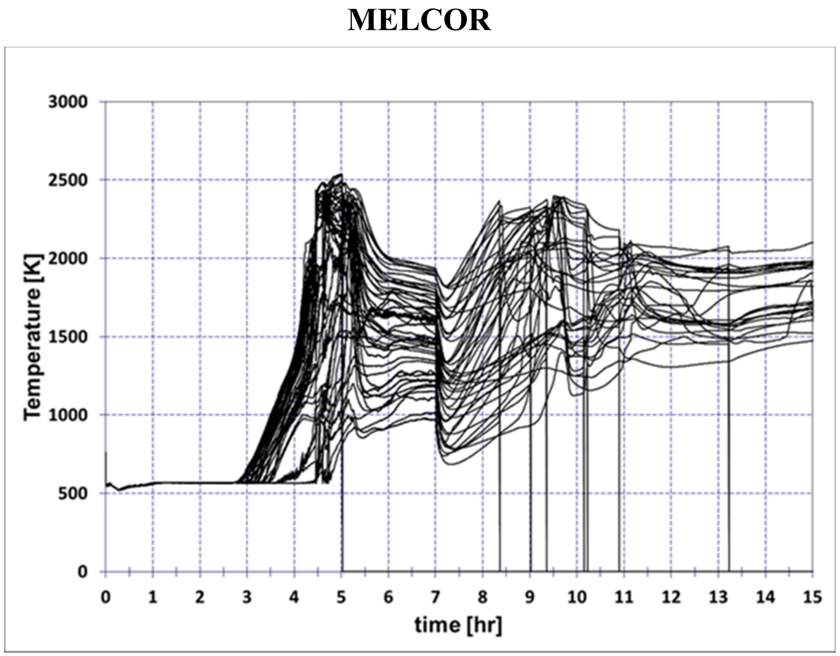




- MAAP5 predicts lower steam dome temperatures compared to MELCOR

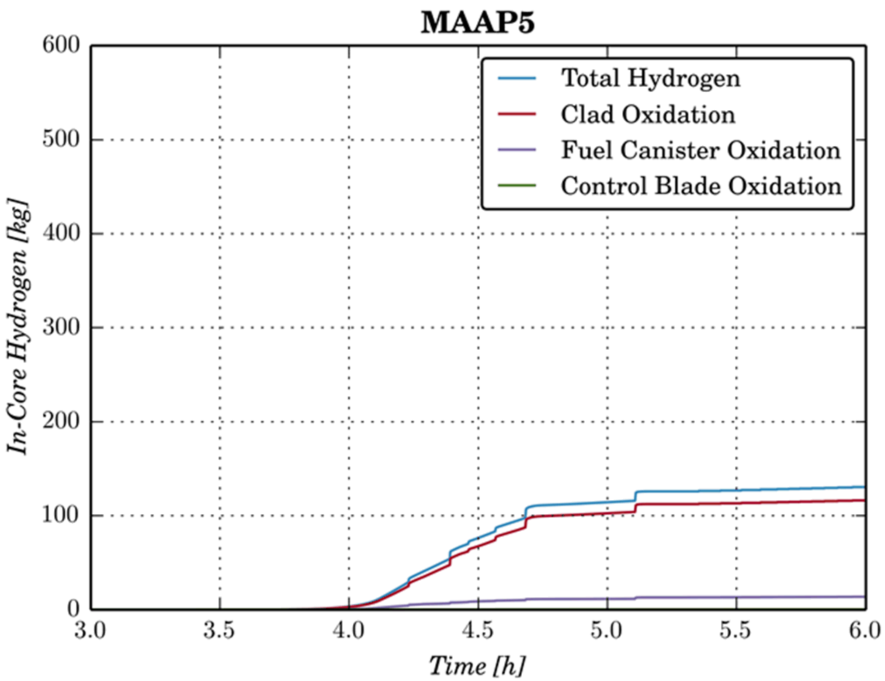
Fuel Temperature

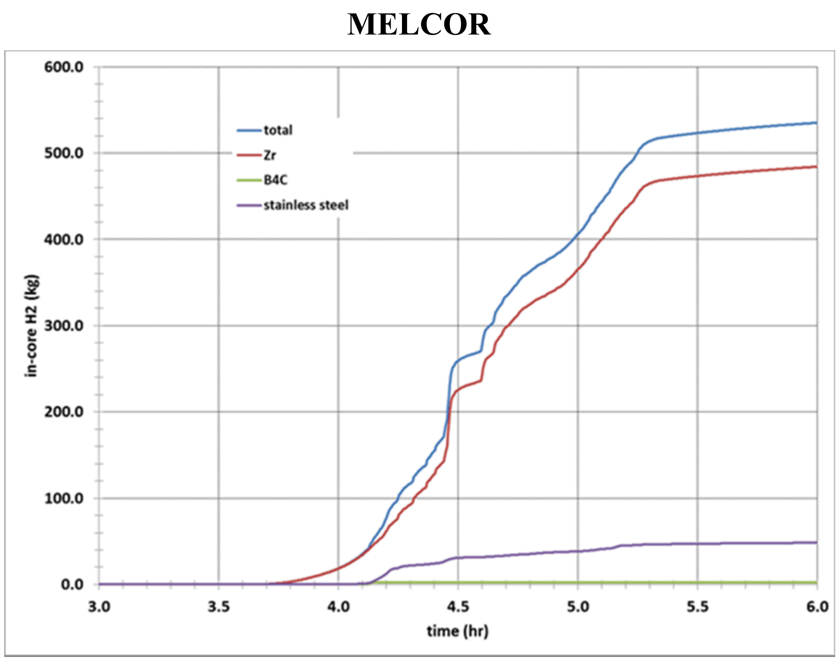




- MAAP5 predicts higher fuel temperatures compared to MELCOR

Hydrogen Generation





- MELCOR predicts higher hydrogen generation compared to MAAP5

Future Work (Phase 2?)

- Detailed examination/comparison of heat transfer from particulate debris
  - Involvement of code developers likely needed
- SRV venting interaction with the wetwell
  - Stand-alone models with “identical” boundary conditions
  - Heat transfer to wetwell pool
  - Pool scrubbing of source term
- Simulation of Recovery Actions
  - Water injection recovery prior to significant loss of the rod-like core geometry
  - Water injection recovery following significant loss of rod-like geometry
  - Water injection following core slumping into the lower plenum
- Ex-Vessel Core Melt Progression
  - Stand-alone models with “identical” boundary conditions
  - Axial and radial concrete ablation
  - Containment heating and pressurizations
  - Source term generation
- Investigation of Simulation Uncertainties