RIC2010
MELCOR DEVELOPMENT ACTIVITIES AND RECENT APPLICATIONS

Hossein Esmaili
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OUTLINE

- Application of MELCOR to Design Certification for New Reactors
- Development of MELCOR Fission Product Release Models for Gas Cooled Reactors
- Application of MELCOR to Evaluation of System Success Criteria
- Development and Application of MELCOR Accident Simulation Using SNAP

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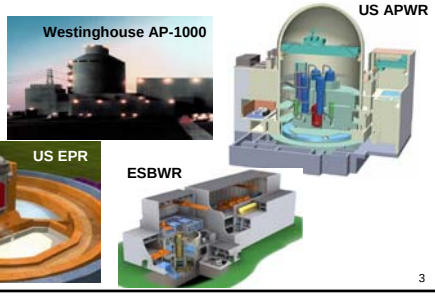
Design Certification

- Severe accident response and source term
- Containment response to design basis accident



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Design Certification

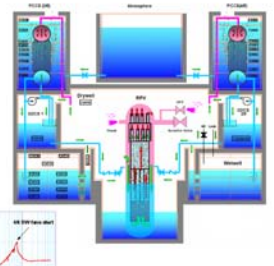
ESBWR Long Term Cooling

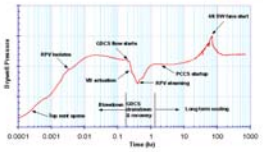
First 3 days (Passive Period)

Dominant phenomena include core radiolysis causing PCCS non-condensable gas bounding and bypass leakage of steam from drywell to wetwell

Post 3 days (Intervention Period)

- Drywell recirculation fans
- PCCS pool refill
- PARs credited





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HTGR FP Release

- Develop HTGR specific fission product release and transport models for MELCOR
  - Use existing MELCOR models for fission product transport and deposition in the primary system and containment
  - Implement diffusional release models for both intact and failed TRISO fuel particles
  - Implement diffusional release model for matrix and graphite block
  - Applicable to both pebble bed and prismatic designs
  - Calculate releases for both normal operation and accident conditions
- Basic approach similar to LWRs
  - Code used for independent confirmatory (audit) calculations

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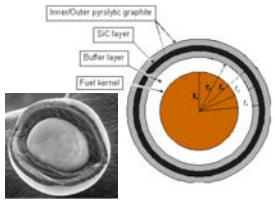
TRISO Particle FP Release

- FP release from kernel involves both diffusion and recoil
- For failed particles, release from kernel
- For intact particles, release is controlled by SiC layer



$$\frac{\partial C}{\partial t} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 D \frac{\partial C}{\partial r}\right) - \lambda C + \beta$$

$$\frac{\partial C}{\partial r} = 0 ; (r = 0)$$

$$C = 0 ; (r = R)$$

C = Concentration (1/m^3)
D = Diffusion coefficient (m^2/s)
λ = Decay constant (1/s)
β = Generation rate (1/m^3-s)

Kernel generation ~ yield x power
Buffer generation due to recoil ∝ kernel generation

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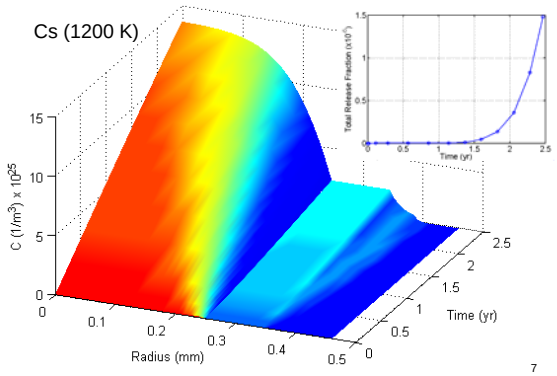
Intact TRISO Particles



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MELCOR Steady State

- Perform “Accelerated” Steady State Run with MELCOR to Get FP and Dust Distribution in the System
  - Dust and FP release during normal operation
  - Use existing models in MELCOR for FP transport and deposition on surfaces
  - Need to be run long enough to establish trends and/or equilibrium
  - Scale to desired operating time
  - Use as initial condition for accident analysis

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Success Criteria Application

- Application of MELCOR to update basis for PRA treatment of specific operator timing and mitigation system effectiveness issues of interest
- Detailed SOARCA MELCOR 1.8.6 models for Surry and Peach Bottom used
- Many calculations intentionally assume minimal operator action and are allowed to proceed to core damage to:
  - Establish minimal equipment configurations
  - Establish timings for human error probability (HEP) evaluations
  - Establish time window for AC power recovery
- For the above reason, many results do not correspond to the best-estimate integrated plant response to a given initiator; they do correspond to the best-estimate simulation given the prescribed boundary conditions

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Success Criteria Application

- Results are documented in an August 2009 report available in the NRC's Agencywide Document Accession and Management System (ADAMS) at accession number ML091890792
- Additional analysis and documentation enhancement planned
- Work commenced at Sandia National Labs to look at additional aspects (e.g., core damage surrogates)
- Extension to other plants planned (e.g., 4-loop large, dry)
- Possible future information exchanges with industry

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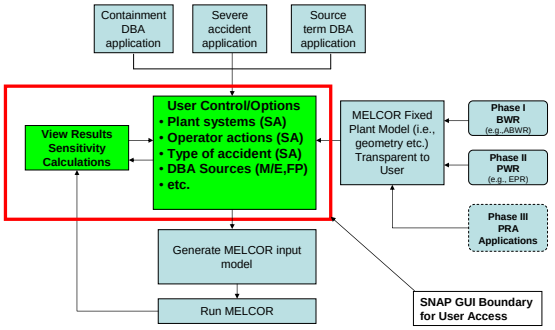
Accident Simulation Using SNAP



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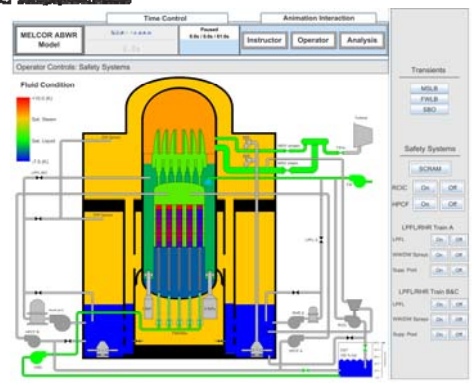
Accident Simulation Using SNAP



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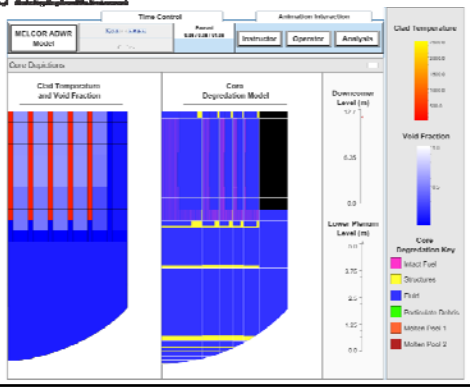
Accident Simulation Using SNAP



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Acronyms

- BWR Boiling Water Reactor
- DBA Design Basis Accident
- FP Fission Product
- HTGR High Temperature Gas Reactor
- PAR Passive Autocatalytic Recombiner
- PBR Pebble Bed Reactor
- PCCS Passive Containment Cooling System
- PMR Prismatic Modular Reactor
- PRA Probabilistic Risk Assessment
- PWR Pressurized Water Reactor
- SA Severe Accident
- SNAP Symbolic Nuclear Analyzer Package
- SOARCA State-of-the-art Reactor Consequence Analysis
- SPAR Standardized Plant Analysis Risk

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