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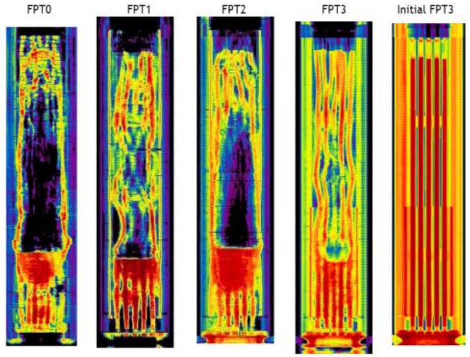


Using a MELCOR/ADAPT Framework to Walkthrough SAMGs

Nathan C. Andrews, Doug Osborn, Jeff Cardoni, Matt Denman,
Zac Jankovsky, Randall Gauntt

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

NNSA National Nuclear Security Administration

SAMG Walkthrough – Overview

- Identify the key scenarios for a BWR and PWR that may lead to beyond design basis events; e.g., SBO, SGTR
- Simulate the scenarios and through symptoms expressed by the simulation, consider key SAMG operator actions to mitigate the accident
- Accident signatures would take into account potential failures in the operator actions as well as uncertainties in the severe accident simulation
- Simulate scenarios via:
  - MELCOR (Severe Accidents Analysis Code)
  - ADAPT (Dynamic Branching Wrapper)

SAMG Walkthrough - ADAPT

- ADAPT splits scenario at key times
- Developed visualization tool to focus on parameters of interest
  - Returns portions of tree meeting a set of rules
    - e.g., branches with water level below TAF at t<40 min and lower head penetration failure at t>4 hr
- Developed dynamic importance measures to determine impact of parameters
  - Events: return ratio of a measure of consequence (e.g. extent of radionuclide release) for event occurrence vs non-occurrence
    - Compatible with non-binary branching
    - e.g. events with both uncertain occurrence and timing
  - Physical parameters: return ratio of consequence measure for each sampled value vs overall

SAMG Walkthrough - Work to Date

- Run-down of an SAMG scenario industry representatives
  - Steady State Operation → Initiating Event→ EOP → SAMG
- Developed scenario based off of EOPs, TSGs, SAMGs and expert opinion
  - Attended TSG workshop and received BWROG EPC guidance
  - Informed by ex-vessel analysis experts– Kevin Robb, Mitch Farmer
- ADAPT framework for queuing MELCOR cases
  - Updates and setup of scenario framework
  - Dynamic approach: single run that diverges at key times
    - Pump failure or start-up
    - Different injection rates
    - Water injection timings based on different pressure signatures
- Initial simulations of SAMG scenario into EOP and SAMG space

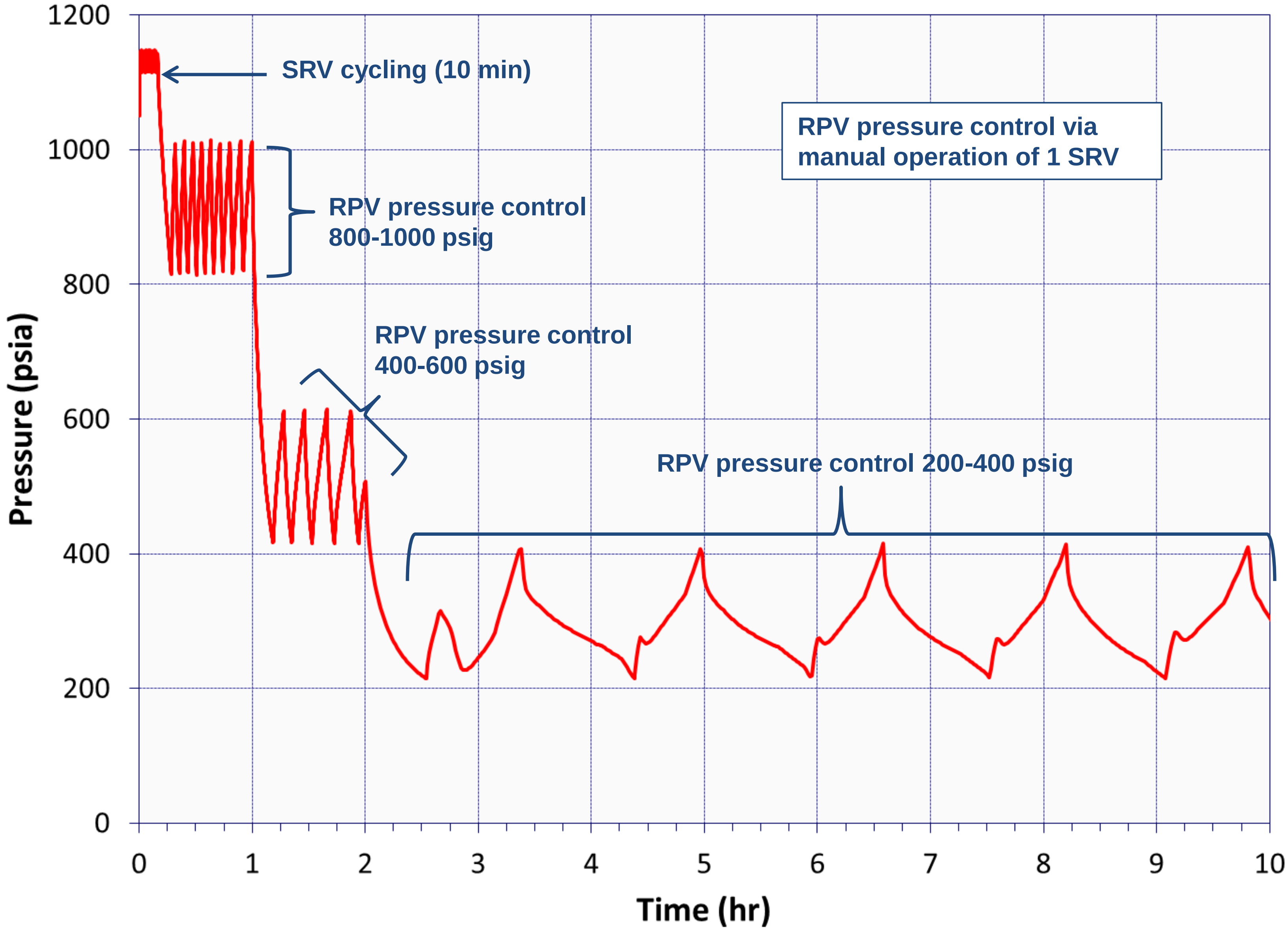
SAMG Guidance - Metrics

- Event timings
  - Water levels: TAF, BAF
  - Zr-oxidation pickup
  - Core plate
  - Lower head failure
  - Ex-vessel signatures
- Long-term water management
  - SAWA
  - SAWM
  - Different long-term injection rates into the PCV
  - Impact on total release (accident source)
- Assess impact of different models within MAAP and MELCOR on event scenario
  - In-vessel treatment of core relocation
  - Core quenching
  - Lower head failure modeling
  - MCCI model impact on long-term PCV behavior
    - Ex-vessel gas generation
    - Debris coolability

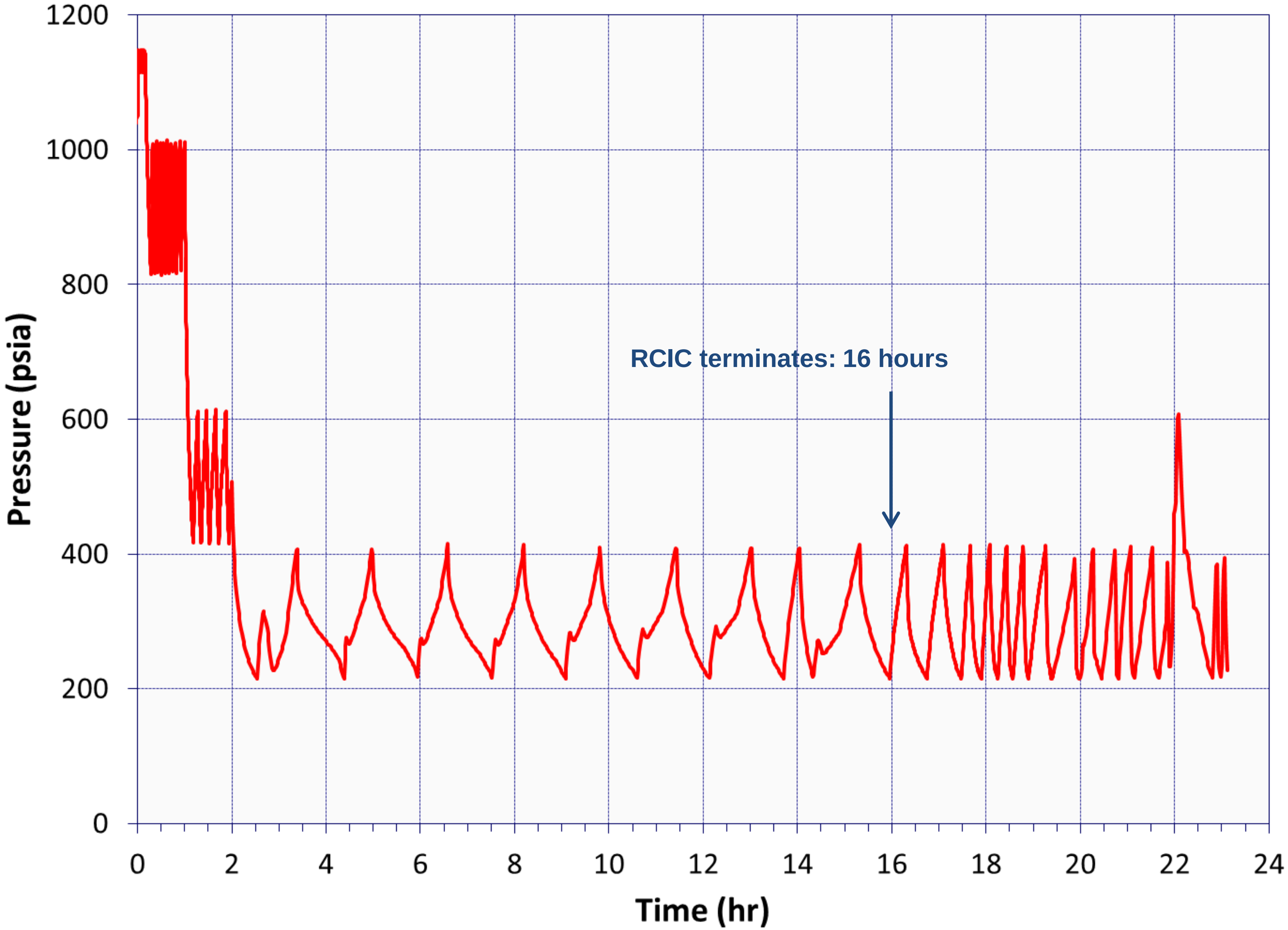
Initial SAMG Scenario Runs

- Base case for ADAPT-MELCOR run
  - Subsequent runs will be horsetail plots showing different operator actions, decisions and bifurcation points
  - Steady State Operation → Initiating Event→ EOP → SAMG
- Based on accident scenario that was iterated on by EPRI, Exelon (Phil Amway) and Sandia
  - SRV cycling
  - RPV pressure control via manual operation of 1 SRV
  - Containment venting
  - RCIC operation
- Currently past the point of SAMG entry
  - Significant simulation of EOP space
    - RPV Pressure Control
    - RCIC operation
    - Drywell venting
  - Importance of capturing stratification within the wetwell

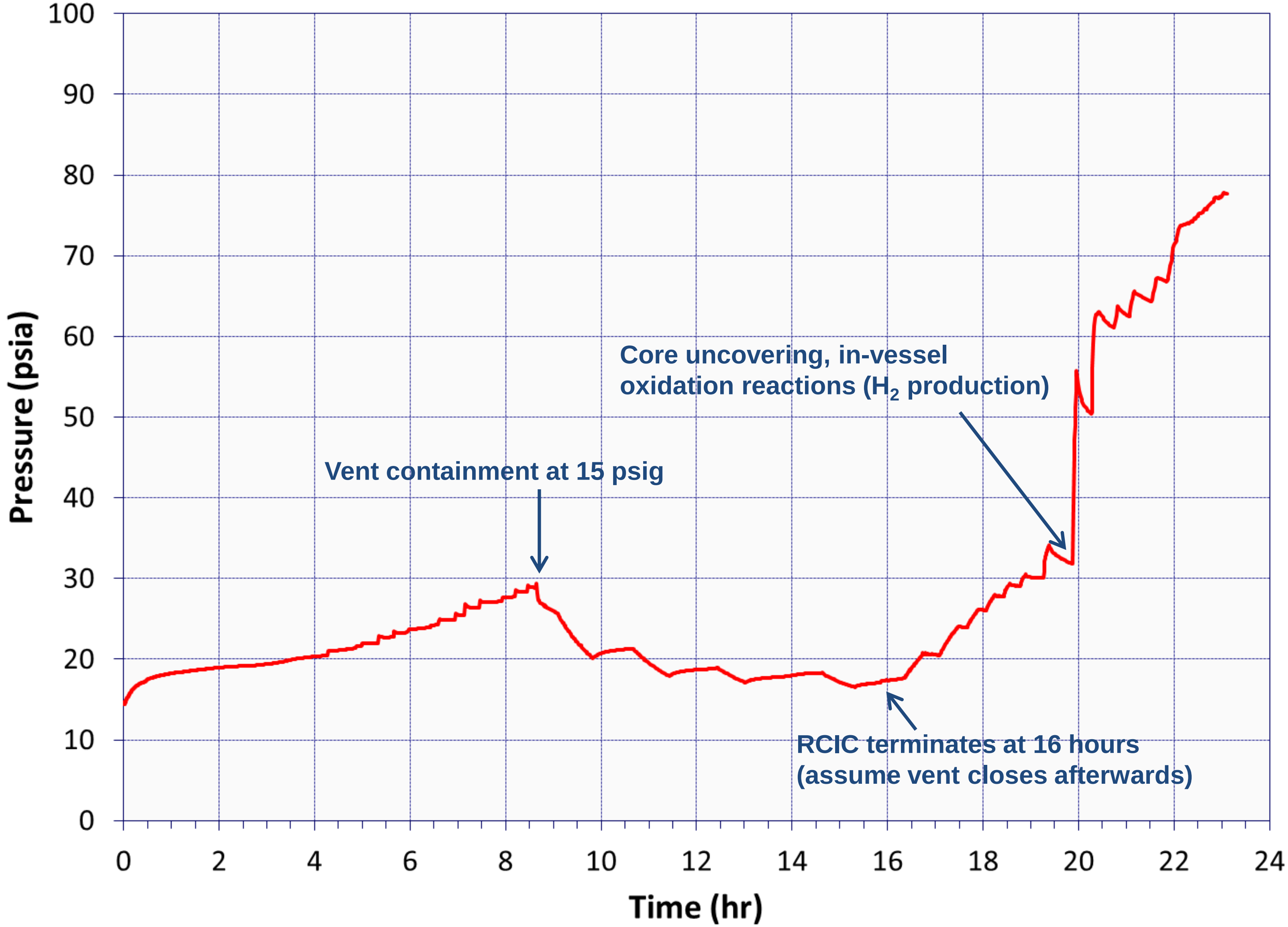
SAMG Case: RPV Pressure (0-10 hrs)



SAMG Case: RPV Pressure (0-24 hrs)

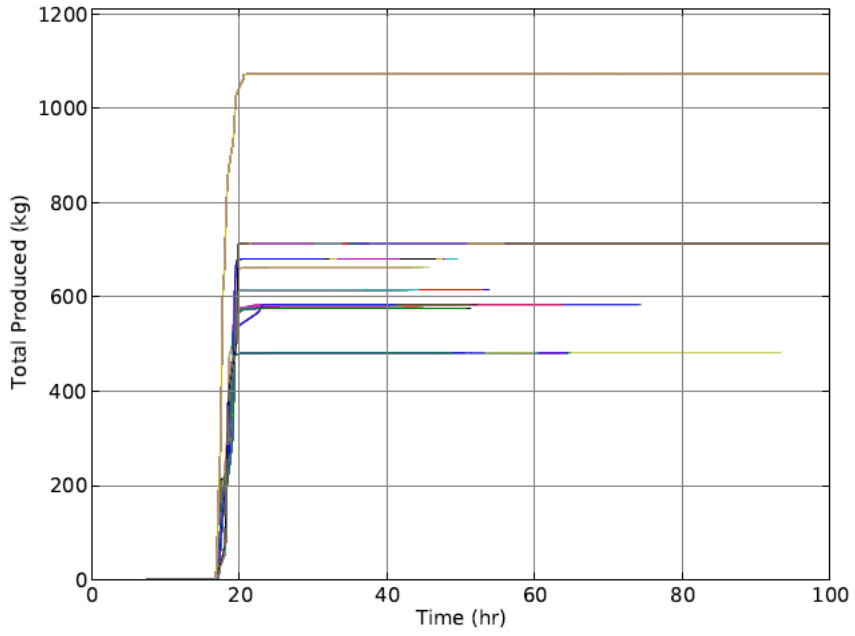


SAMG Case: Drywell Pressure

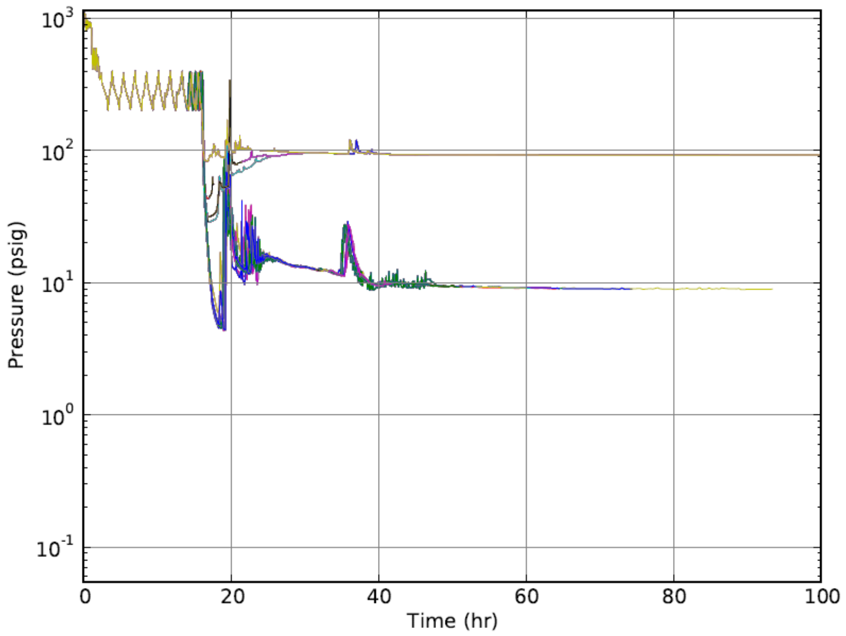


Sample ADAPT Horsetail Plots

In-Vessel Hydrogen Production



RPV Pressure



Role of Suppression Pool Stratification in Accident Management

- Previous plot shows wetwell goes saturated during venting
- Two advantages
  - 1) Wetwell venting releases water that has high specific enthalpy and leaves behind cooler water with lower specific enthalpy thereby maximizing decay heat rejection with minimal water loss
  - 2) A subcooled lower water level could help maintain NPSH for the RCIC pump
- RPV pressure control
  - Using only one SRV might be preferable if it minimized suppression pool mixing
  - As opposed to the "circle around the pool" method that would lead to more mixing
- Significant optimization of the EOP leading to SAMG
  - Seek to demonstrate this by modeling a stratified suppression pool in MELCOR

Professional Conferences/Papers

- Z. Jankovsky, M. Denman, T. Aldemir, “Dynamic Importance Measures in the ADAPT Framework,” submitted to the Amercian Nuclear Society Winter Conference, Las Vegas, NV. (2016).
- Z. Jankovsky, M. Denman, T. Aldemir, “Conditional Tree Reduction in the ADAPT Framework,” submitted to the American Nuclear Society Winter Conference, Las Vegas, NV. (2016).
- Z. Jankovsky, M. Denman, T. Aldemir, “Extension of the ADAPT Framework for Multiple Simulators,” submitted to the American Nuclear Society Winter Conference, Las Vegas, NV. (2016).

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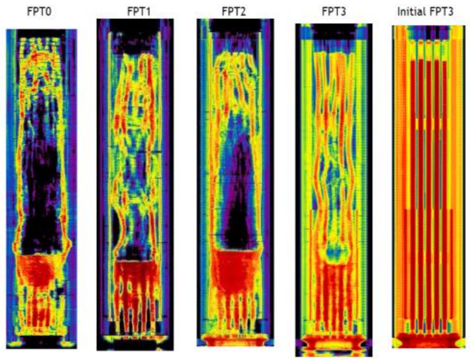


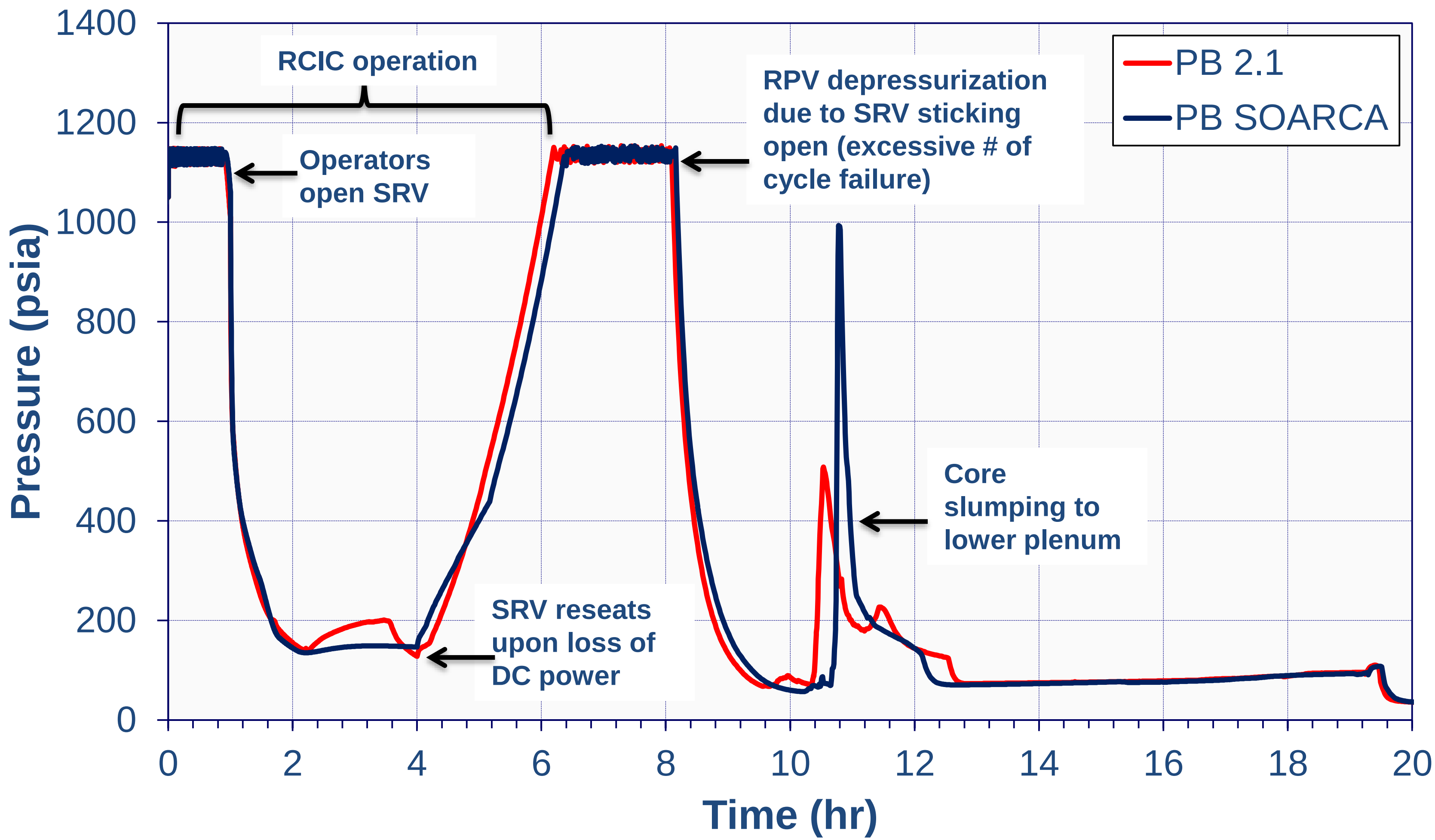
BACKUP SLIDES

Peach Bottom Long-term Station Blackout, Case Verification

- Key sequence assumptions identical to SOARCA scenarios:
  - LTSBO with 4 hours of DC power
  - Operators manually depressurize RPV via SRV at 1 hour
  - RCIC operation is available
  - Loss of DC power results in reseating of the open SRV and it ‘locks’ the current RCIC flow rate
  - Locked RCIC flow typically yields RPV overfill and liquid ingress into RCIC turbine
    - liquid ingress is assumed to instantly terminate RCIC operation
  - No further mitigative actions are credited (e.g. venting, RPV injection, sprays)
- RCIC flow ends later in MELCOR 2.1
  - RCIC flow terminates upon MSL flooding and water ingress into turbine
  - Slightly different timing of MSL flooding in 2.1 calculation
- Boildown time is not significantly effected
- SRV failure time is nearly identical between versions

Event	MELCOR 1.8.6	MELCOR 2.1
RCIC flow terminates	5.2	6.0
SRV failure	8.2	8.1
Downcomer water level reaches TAF	8.4	8.2
RPV water level reaches core plate	9.3	9.0

PB LTSBO: RPV Pressure



PB LTSBO: Drywell Pressure