



# Key Sources of Uncertainty in Shutdown Risk for Operating Plants

NRC\EPRI Workshop  
Treatment of PRA Uncertainties  
February 29, 2012

Marie Pohida,  
Senior Reliability and Risk Analyst

- Type of Outage
  - Forced outage to make a repair
    - RCS instrumentation line, RCS stop valve, SG tubes, RCP
    - Repairs requiring reduced inventory operation with high decay heat levels can increase risk
  - Refueling outages (could also include)
    - Midloop to isolate SGs to inspect tubes (PWRs)
    - Repairs of systems connected to the RCS (example RWCU, BWRs)
    - Repairs of Mitigating Systems

February 29, 2012

- Exactly how/when plant is “taken apart” during the outage
  - Method for RCS draining
    - PWR draining with RCS intact
    - PWR draining with RCS open (e.g. pZR manway)
    - Licensee following guidance in GL 88-17?
    - Licensee preventing Sudden Loss of RCS Inventory (IN 88-36)?
  - Method for RCS filling and draining refueling cavity
  - RCS vent paths during the outage
    - Open SG or Pressurizer Manways, Head removal, etc.
  - PWR Water Solid Conditions
  - Containment Status (open, closed, de-inerted, etc.)

February 29, 2012

- **Availability** of Mitigating Systems to provide
  - RCS injection or Gravity drain
  - Decay Heat Removal
    - Residual Heat Removal
    - Steam Generator Cooling
    - Alternate Decay Heat Removal Systems
  - Containment Closure
  - Instrumentation necessary to perform these functions (CETs, RCS level instrumentation, etc)
  - Following Guidance in NUMARC 91-06?

February 29, 2012

## Influence on Operator Error

- Type of outage
- Method of taking the plant apart
- Availability of mitigating SSCs and instrumentation
- Adequacy of procedures
- These conditions dictate:
  - Initiating events to be considered
  - Plant response to a loss of DHR and/or Loss of Inventory event
  - Operator actions and timing to prevent core damage and release.
- The actual risk lies in the details of the outage.

February 29, 2012

# Key Sources of Uncertainty and the LPSD STD

High Level Requirement	Source of Model Uncertainty	How source of uncertainty manifested in PRA	Significance of Model Uncertainty
HLR-POS-A	Definition of POSs	POS definition is complete and corresponds to anticipated outage conditions, POSs not screened based on ‘perceived’ low risk	High*
HLR-IE-A	List of IE	Complete; considers key activities in outage	High*

\*High – source of uncertainty could significantly impact CDF/LERF results and risk insights

# Key Sources of Uncertainty and the LPSD STD

High Level Requirement	Source of Model Uncertainty	How source of uncertainty manifested in PRA	Significance of Model Uncertainty
HLR-AS-A	Plant response to initiator	Will mitigating systems really work given actual POS conditions (ex. Gravity Injection with high RCS elevation vents, SG cooling with Nitrogen cover gas, Containment closure needs polar crane)	High*

\*High – source of uncertainty could significantly impact CDF/LERF results and risk insights

# Key Sources of Uncertainty and the LPSD STD

High Level Requirement	Source of Model Uncertainty	How source of uncertainty manifested in PRA	Significance of Model Uncertainty
HLR-HRA-F	Timing for Operator Actions	<p>RCS response to loss of DHR and/or Loss of RCS Inventory</p> <p>Time to isolate drain path, Time to RCS boiling, Time to steaming inside containment, Time to core damage, Time to RWST depletion</p>	High*

\*High – source of uncertainty could significantly impact CDF/LERF results and risk insights



# Key Sources of Uncertainty and the LPSD STD

High Level Requirement	Source of Model Uncertainty	How source of uncertainty manifested in PRA	Significance of Model Uncertainty
HLR-HRA-G	Human Error Rate assigned to post-initiator operator action	<p>Availability of Cues/Instrumentation and Alarms</p> <p>Dependency on prior human failure events</p> <p>Completeness/Applicability of procedures</p> <p>Cutoff values for multiple HEPs in an AS?</p> <p>Long recovery periods = very low operator failure rates?</p>	<p>High*</p> <p>High*</p> <p>High*</p> <p>High*</p> <p>High*</p>

\*High – source of uncertainty could significantly impact CDF/LERF results and risk insights

# Key Sources of Uncertainty and the LPSD STD

High Level Requirement	Source of Model Uncertainty	How source of uncertainty manifested in PRA	Significance of Model Uncertainty
HLR-EXT-E	Site Impacts and Initiating Event Frequency	Impact on SSCs  Drywell Head Removed?  PWR equipment hatch open? RCS temporary penetrations installed?  Fire barriers removed/opened?  Nonsafety related equipment?  Local operator actions?	High*

**\*High – source of uncertainty could significantly impact CDF/LERF results and risk insights**