



# JENSEN HUGHES

Advancing the Science of Safety

## **LIKELIHOOD THAT SHORT TERM STATION BLACKOUT SCENARIOS LEAD TO A LARGE AND EARLY RELEASE**

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September 27, 2017**

# PRESENTATION TOPICS

- Background
- Modeling approach
- Relevant considerations for a Large and Early Release (LER)
- Integrated LER likelihood estimate results
- Conclusions



# LERF IN STSBO BACKGROUND

- Large Early Release Frequency (LERF) risk metric used in risk-informed applications
- Mark I BWRs generally have assumed a high conditional likelihood of LER in Short Term Station Blackout (STSBO) scenarios
  - Contribution from liner melt-through of containment following vessel failure
- Considerable uncertainty associated with exact timing and magnitude of release
  - Potential exists that release is not large and/or not early



# LERF IN STSBO MODELING APPROACH

- Identify key inputs to estimate LER likelihood
- Relevant considerations
  - General Emergency (GE) declaration and Evacuation Time Estimates (ETEs)
  - Core melt progression characteristics (e.g., stuck open relief valve, steam line rupture, timing of vessel failure, fission product location)
  - Timing of “large” threshold release
- Provide uncertainty distribution for each key input
  - Integrate using Monte Carlo uncertainty evaluations



# RELEVANT CONSIDERATIONS FOR LERF

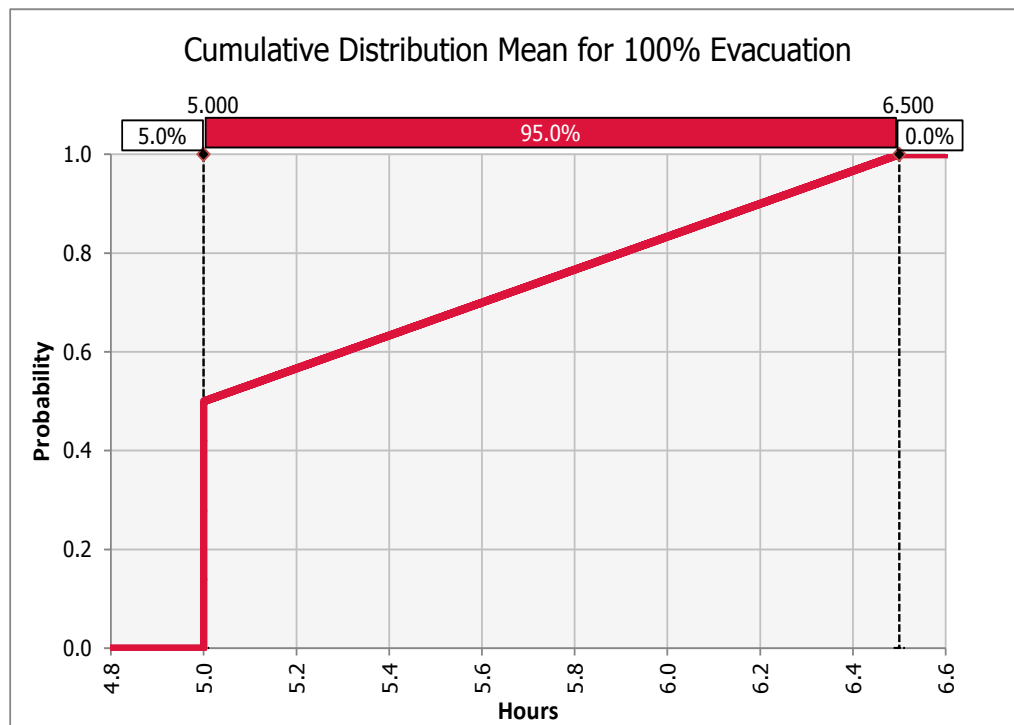
- General Emergency (GE) declaration and Evacuation Time Estimate (ETEs)
  - The STSBO scenario will lead to an early declaration of a GE
  - ETEs are available from recent emergency planning study for a variety of conditions

Conditions	Evacuation Advisory (Hours)	ETE for 100% Population out to EPZ (Hours)	Evacuation Time from Sequence Initiation (Hours)
Good to Poor	1.0 to 1.5	4.0 to 5.0	5.0 to 6.5



# RELEVANT CONSIDERATIONS FOR LERF

- Assumed cumulative probability distribution for time to 100% evacuation



# RELEVANT CONSIDERATIONS FOR LERF

- Core melt progression characteristics
- Two key phenomena have first order impact on fission product location at time of containment failure
  - Likelihood of a Stuck Open Relief Valve (SORV)
  - Likelihood of Steam Line Rupture (SLR)
- NRC SOARCA study indicated very high likelihood of SORV (i.e., assumed SORV in base case analysis)
  - Large number of SRV cycles
  - Thermal degradation mechanisms
- In our analysis, assume 95% likelihood of a SORV during core melt progression



# RELEVANT CONSIDERATIONS FOR LERF

- NRC SOARCA study investigated likelihood of SLR (only assumed in sensitivity cases)
  - Extreme variations to the SORV failure criteria were needed to obtain conditions that would allow SLR to occur
    - Prolonged SRV cycling, or
    - Partial opening of SORV such that additional SRV cycles are precluded but RPV pressure stays high
- In our analysis, assume 10% likelihood of a SLR during core melt progression
  - This is assumed to be a subset of the SORV likelihood





# RELEVANT CONSIDERATIONS FOR LERF

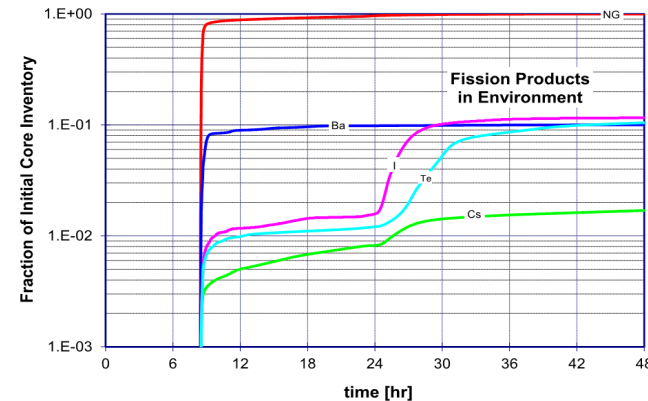
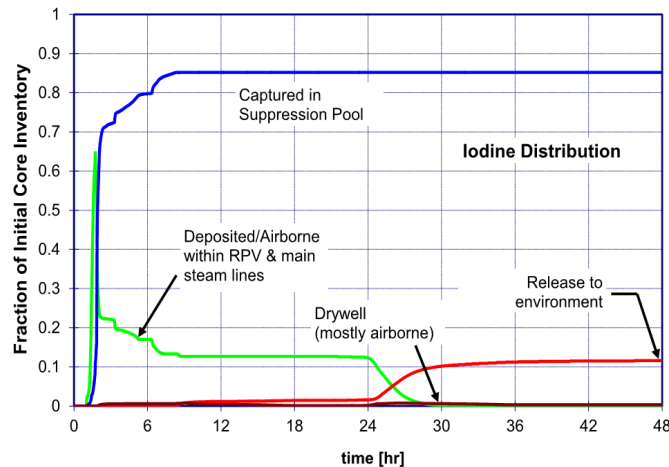
- Core melt progression characteristics – base case likelihood assumptions

Designator	Description	Likelihood
SORV	Stuck Open Relief Valve Occurs	0.85
SLR	Steam Line Rupture Occurs	0.10
HP	RPV Remains at High Pressure	0.05



# RELEVANT CONSIDERATIONS FOR LERF

- Timing of “large” threshold release
- SOARCA results from MELCOR for STSBO with SORV and no injection



- Results indicate virtually no chance of a large and early release



# RELEVANT CONSIDERATIONS FOR LERF

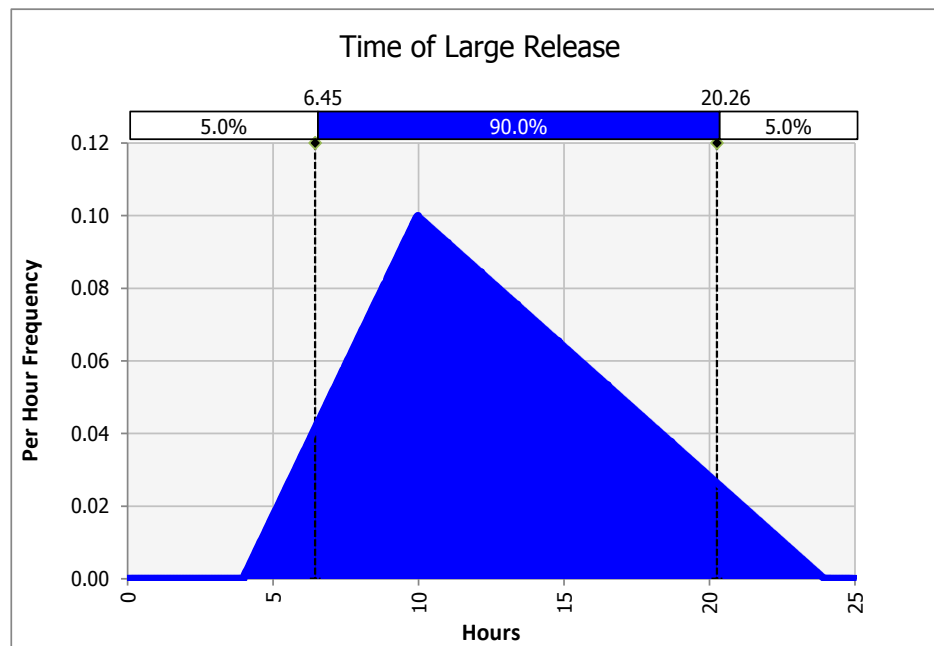
- However, not all case results are in agreement

Event	MAAP4.06	MELCOR	MAAP5.03	MAAP5.04
H2 Production Begins	36 Min.	55 Min.	50 Min.	42 Min.
SRV Sticks Open	1.8 Hrs.	1.8 Hrs.	1.8 Hrs.	1.1 Hrs.
Vessel Failure	3.8 Hrs.	8.2 Hrs.	8.0 Hrs.	3.6 Hrs.
Drywell Liner Mel-Through	3.9 Hrs.	8.5 Hrs.	8.2 Hrs.	3.8 Hrs.
Iodine or CsI release exceeds 1%	4.0 Hrs. (~4% shortly after that and slowly climbs)	9.7 Hrs.	> 24 Hrs.	4.0 Hrs. (~2% shortly after that and slowly climbs later on)
Iodine or CsI release exceeds 10%	> 24 Hrs.	27 Hrs.	N/A (at 48 Hrs.)	N/A (at 48 Hrs.)



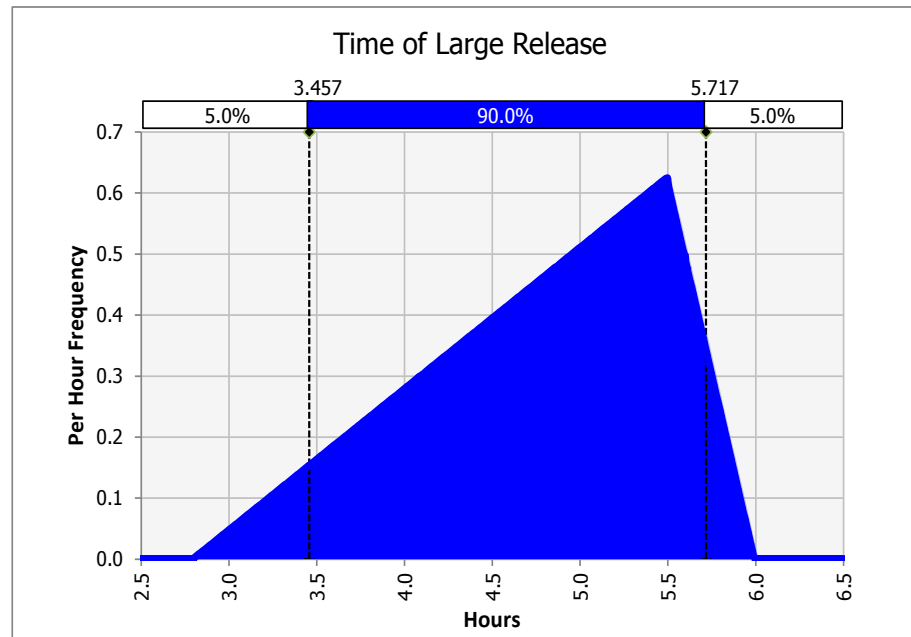
# RELEVANT CONSIDERATIONS FOR LERF

- Timing of “large” threshold release
- Assign probability distribution based on uncertainty involved for SORV case



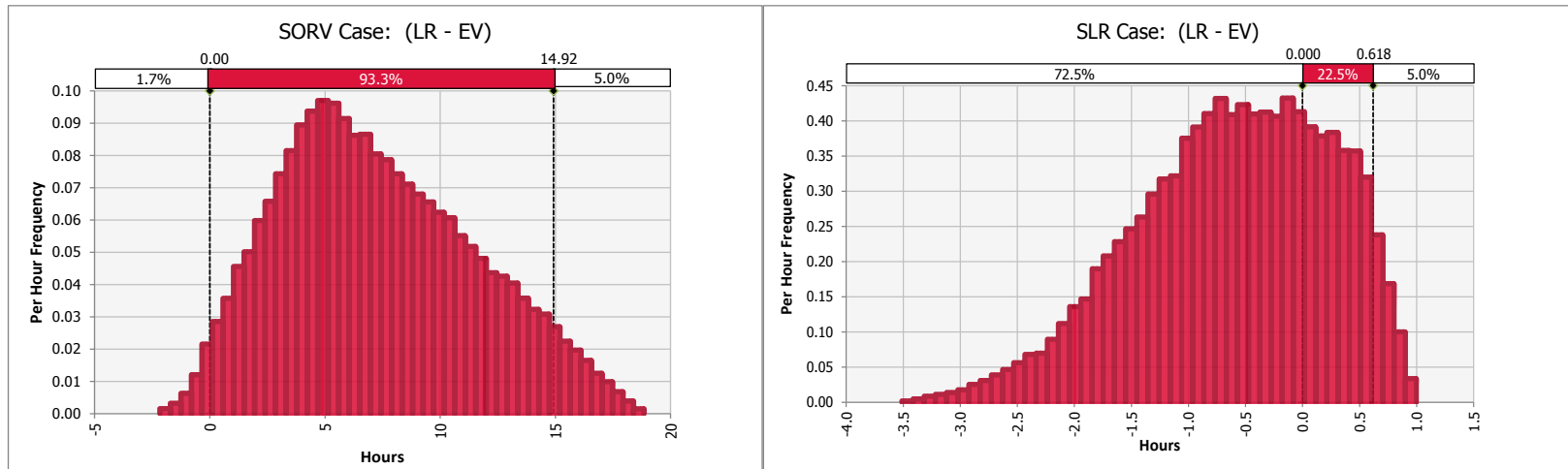
# RELEVANT CONSIDERATIONS FOR LERF

- Timing of “large” threshold release
- Assign probability distribution based on uncertainty involved for SLR and HP cases
  - Much more likely to have ‘large’ release occur earlier in time



# INTEGRATED LER LIKELIHOOD RESULTS

## SORV AND SLR MONTE-CARLO CASE RESULTS

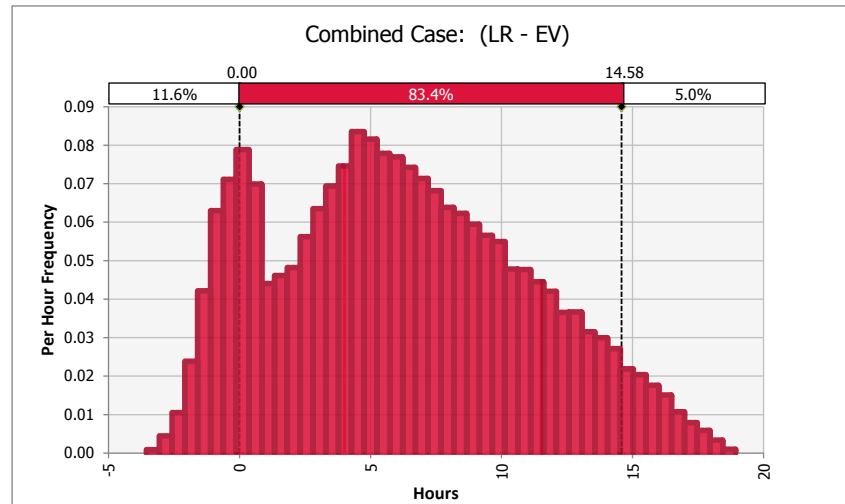


- Only 1.7% chance of LER is SORV scenario
- 73% chance of LER is SLR scenario
- Similarly, 59% of LER in HP scenario



# INTEGRATED LER LIKELIHOOD RESULTS

## OVERALL MONTE-CARLO CASE RESULTS



- Considering assigned uncertainty distributions, less than 12% LER likelihood estimated for STSBO scenarios



# CONCLUSIONS

- NRC SOARCA study indicates very high probability of SORV in STSBO scenario and much lower probability of SLR
- MELCOR and MAAP results both indicate time to “large” threshold may be significantly delayed or not occur at all in SORV scenarios
- Time to “large” threshold will occur much sooner in SLR and HP scenarios
- Integrating various assumptions leads to <12% LER likelihood using Monte-Carlo analysis
- Recommend bounding value of 0.2 be used for risk-informed applications





# QUESTIONS?

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