

Regulatory Engagement Meeting
August 27 2026

Probabilistic Safety Assessment

Public Session

Summary of PSA Work (1)

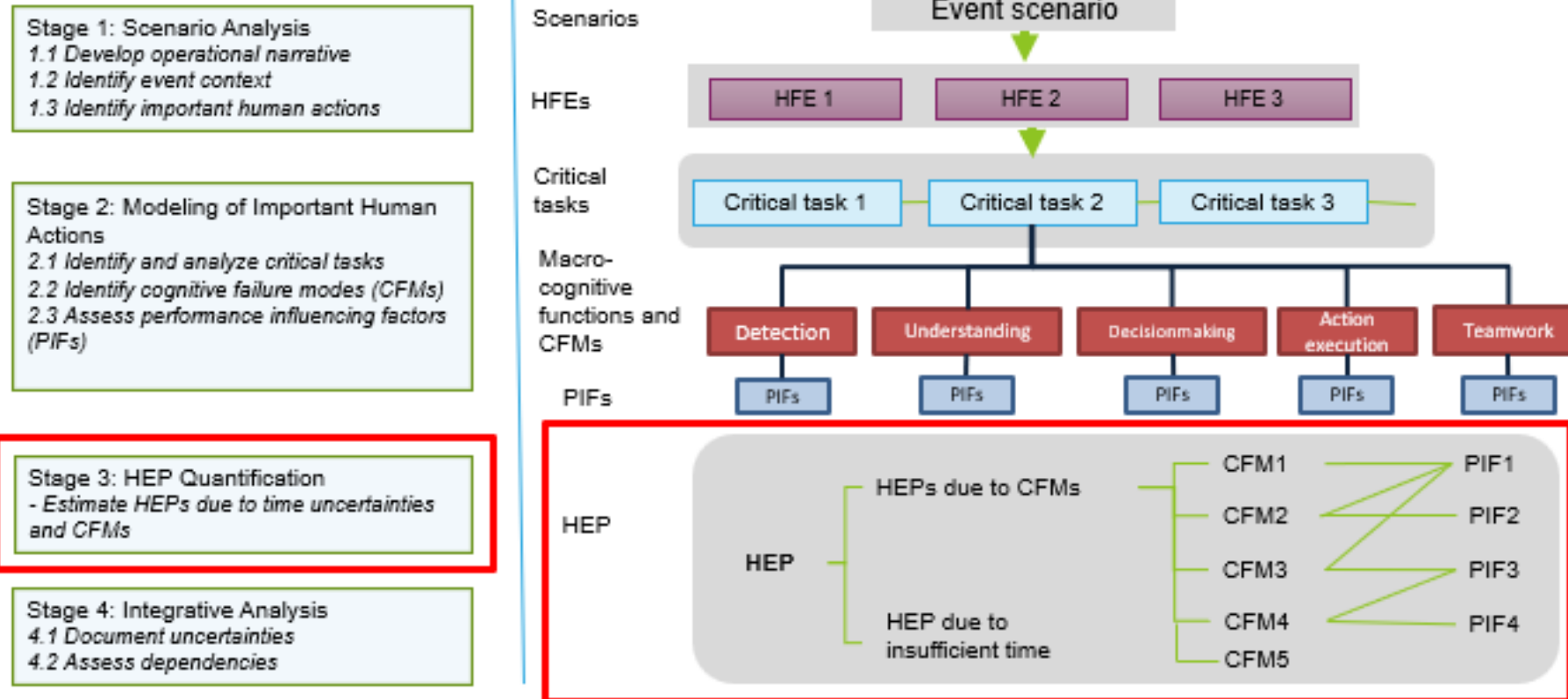
- Event Trees:
 - Transient Overpower
 - Loss of Flow
 - Loss of Heat Sink
 - General Transient
 - Seismic (6 PGA bins)
- End-state categories
 - No fuel damage (NFD)
 - Controlled Stable State (CSS)
 - Fuel damage – Low consequence (FD-LC)
 - Fuel damage – Medium consequence (FD-MC)
 - Fuel damage – High consequence (FD-HC)

Summary of PSA Work (2)

- Key conclusions:
 - Fire PSA follows NUREG/CR-6850 but incomplete due to lack of design data
 - Seismic events are the main driver of plant risk
 - For existing internal events, human operator failure has the highest importance measure followed by CCF events
- NRC feedback from the last meeting (2025):
 - **Consider pre-initiating human failure events, which SPAR-H does not cover**
 - **Compare against non-LWR PSA standard**
 - Add RAW and RRW importance measures aside from Birnbaum and FV, for Part 53
 - Human failure probability calculation within seismic PSA
 - Method to choose IEs
 - LPSD PSA

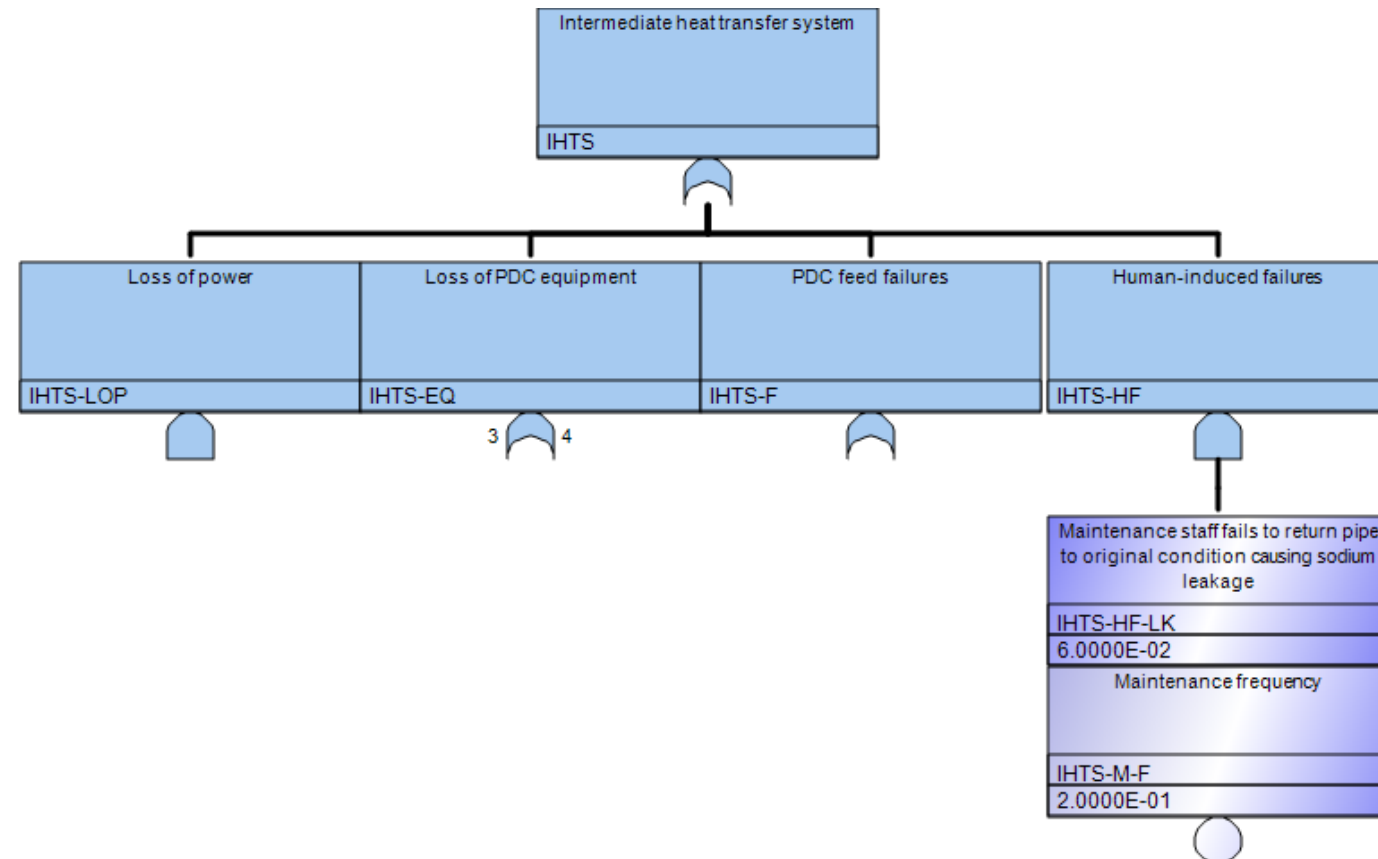
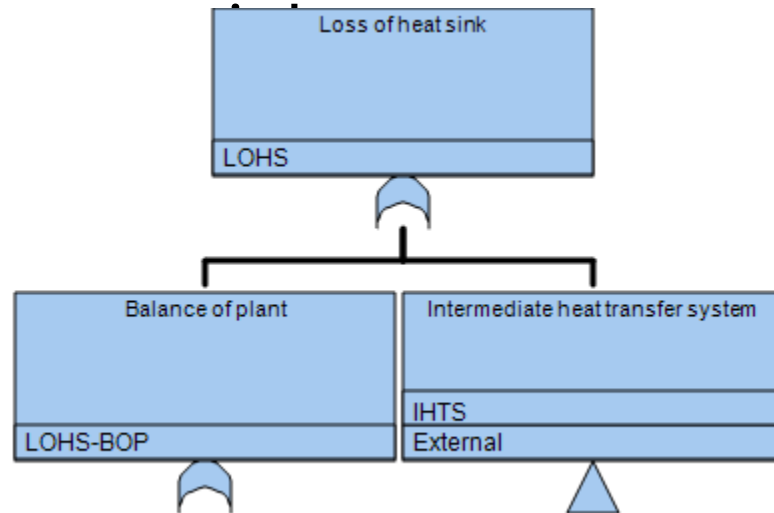
Pre-Initiator Human Failure Events

- NUREG-2256 on Integrated Human Event Analysis System for Event and Condition Assessment (IDHEAS-ECA)



Example

- Workers perform maintenance on sodium piping system but fails to return it to original working condition, leading to loss of heat



Performance Influencing Factors (PIFs)

PIF	PIF Level	Justification
Scenario familiarity	SF0: No impact	It is assumed that workers have a lot of experience in maintenance work and are also familiar with using inspection tools.
Task complexity	C35: Long-lasting action, repeated discontinuous manual control	During maintenance work, workers review procedures and work on tasks while monitoring parameters.
Environmental factors	- ENV3: Heat (>33°C) or high humidity - ENV4: Poor lighting for reading information or execution - ENV8: Wearing heavy protection clothes and/or gloves	When working in the SFR containment building, workers may need to wear protective suits and bring dosimeters and contamination monitoring devices to protect themselves from heat, fire, sodium leakage, and other chemical hazards.
System and I&C transparency	SIC0: No impact	Instrumentation and control (I&C) systems are not related to maintenance work.
Human-system interface	HSI0: No impact	In existing light water reactors (LWRs), human-system interface issues have arisen due to factors such as confusing labels. However, it is generally assumed that SFRs are smaller and simpler than existing LWRs. We can also assume that the issues reported in existing LWRs would not be repeated in the new system due to lessons learned incorporated into training programs and component designs.

PIF	PIF Level	Justification
Critical tools and parts	TP0: No impact	It is assumed that these tools are easy to use and that workers are already well-trained and familiar with them.
Staffing	STA0: No impact	It is assumed that a sufficient number of workers are assigned for maintenance work.
Procedures and guidance	PG0: No impact	It is assumed that procedure instructions are not complicated.
Training and experience	TE0: No impact	Good training and experience are assumed.
Team factors	TF0: No impact	Good teamwork is assumed.
Work practices	WP0: No impact	Good work practice is assumed.
Multi-Tasking, interruption, and distraction	WP0: No impact	No multi-tasking, interruption, and distraction is assumed.
Mental fatigue, stress, and time pressure	MF0: No impact	No mental fatigue, stress, and time pressure is assumed.
Physical demands	PD0: No impact	No physical demand is assumed.

$$HEP = 1 - (1 - P_t)(1 - P_c)$$

P_t: Probability for time-based failures (assumed as 0)

P_c: Probability for cognitive failures

Human Error Probability

NRC IDHEAS-ECA v1.1

Load Data Save Data Close

HFE ID **HFE1** HEP: **6.00E-02** Pc's **6.00E-02** Pt **0.00E00**

Loaded Data File

Documentation **Pt (HFE)** Critical Task 1 (Pc) Critical Task 2 (Pc) Critical Task 3 (Pc)

☒ **Accounted for HEP(HFE)** ID: Critical Task 1 Pc: 6.00E-02

☐ Detection	Recovery	☐ Understanding	Recovery	☐ Deciding	Recovery	☒ Action	Recovery	☐ InterTeam	Recovery
1.00E-04	1	1.00E-03	1	1.00E-03	1	6.00E-02	1	1.00E-03	1

CFM Selection

☐ Detection

☐ Understanding

☐ Decisionmaking

☒ Action

☐ InterTeam

Collapse All

Expand All

Uncheck All

Check All

☒ **Scenario Familiarity**

- ☒ SF0: No impact
- ☐ SF1: Unpredictable dynamics in known scenarios
- ☐ SF2: Unfamiliar elements in the scenario
- ☐ **SF3: Infrequently performed scenarios

☒ **Task Complexity**

- ☐ C30: No impact
- ☐ C31: Straightforward Procedure execution with many steps
- ☐ C32: Non-straightforward Procedure execution
- ☐ C33: Simple continuous control that requires monitoring parameters
- ☐ C34: Continuous control that requires manipulating dynamically
- ☒ C35: Long-lasting action, repeated discontinuous manual control
- ☐ C36: No immediacy to initiate execution
- ☐ C37: Complicated or ambiguous execution criteria
- ☐ C38: Action execution requires close coordination of multiple personnel at different locations

SF0: No impact
 C35: Long-lasting action, repeated d
 ENV3: Heat (>33°C) or high humidity
 ENV4: Poor lighting for reading infor
 ENV8: Wearing heavy protection clo
 SIC0: No impact
 HSI0: No impact
 TP0: No impact

Self Assessment Against ASME/ANS RA-S-1.4

Reserved for the closed meeting session

Regulatory Engagement Meeting August 2026

Probabilistic Safety Assessment

Closed Session Redacted

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May be exempt from public release under the Freedom of Information Act (5 U.S.C. 552), exemption number and category: Exemption 4, commercial/proprietary information.

Department of Energy review required before public release.

Name/Org: Robby Christian / C230 Date: 08/18/2026

Guidance (if applicable) [N/A].

Self Assessment Against **[[**

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- **Plant Operating State**
- **Initiating Events**
- Event Sequence
- Success Criteria Development
- Systems Analysis
- Human Reliability Analysis
- Data Analysis
- Internal Flood PRA
- Internal Fire PRA
- Seismic PRA
- Hazards Screening Analysis
- High Winds PRA
- External Flooding PRA
- Other Hazards PRA
- Event Sequence Quantification
- Mechanistic Source Term Analysis
- Radiological Consequence Analysis
- Risk Integration
- Newly Developed Methods

Plant Operating State (POS)

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Initiating Events (IE)

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IE – cont.

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IE – cont.

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IE – cont.

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IE – cont.

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Investigation of Passive System Failures

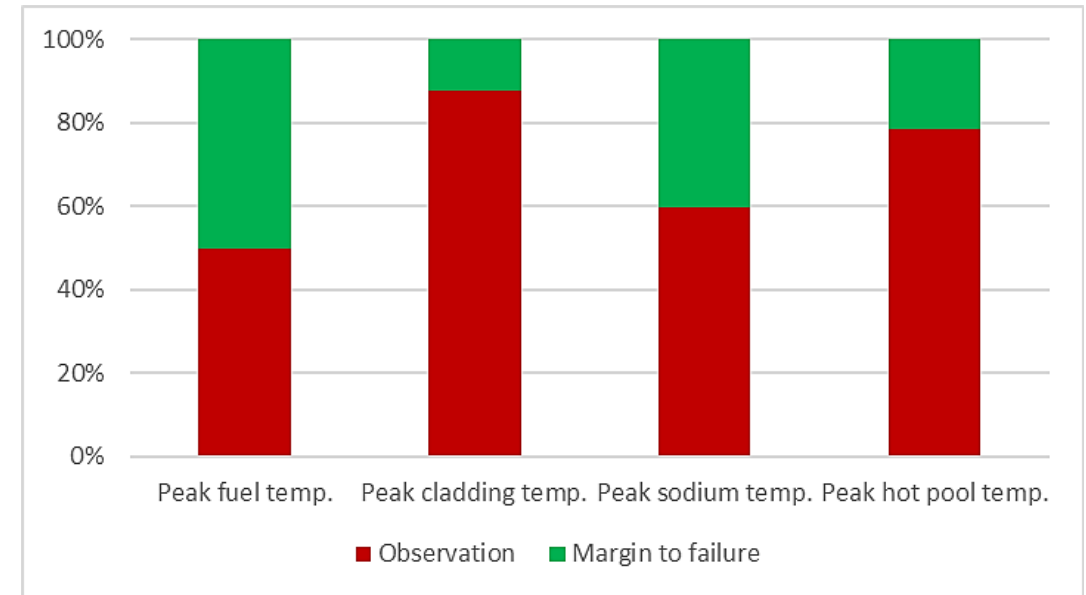
Deterministic analysis

Scenario	RVACS T_Air_In (°C)	DRACS T_Air_In (°C)
Case 0 (nominal)	20	20
Case 1	70	70
Case 2	95	95
Case 3	200	70
Case 4	70 °C with 70% inlet flow rate	All DRACS trains unavailable

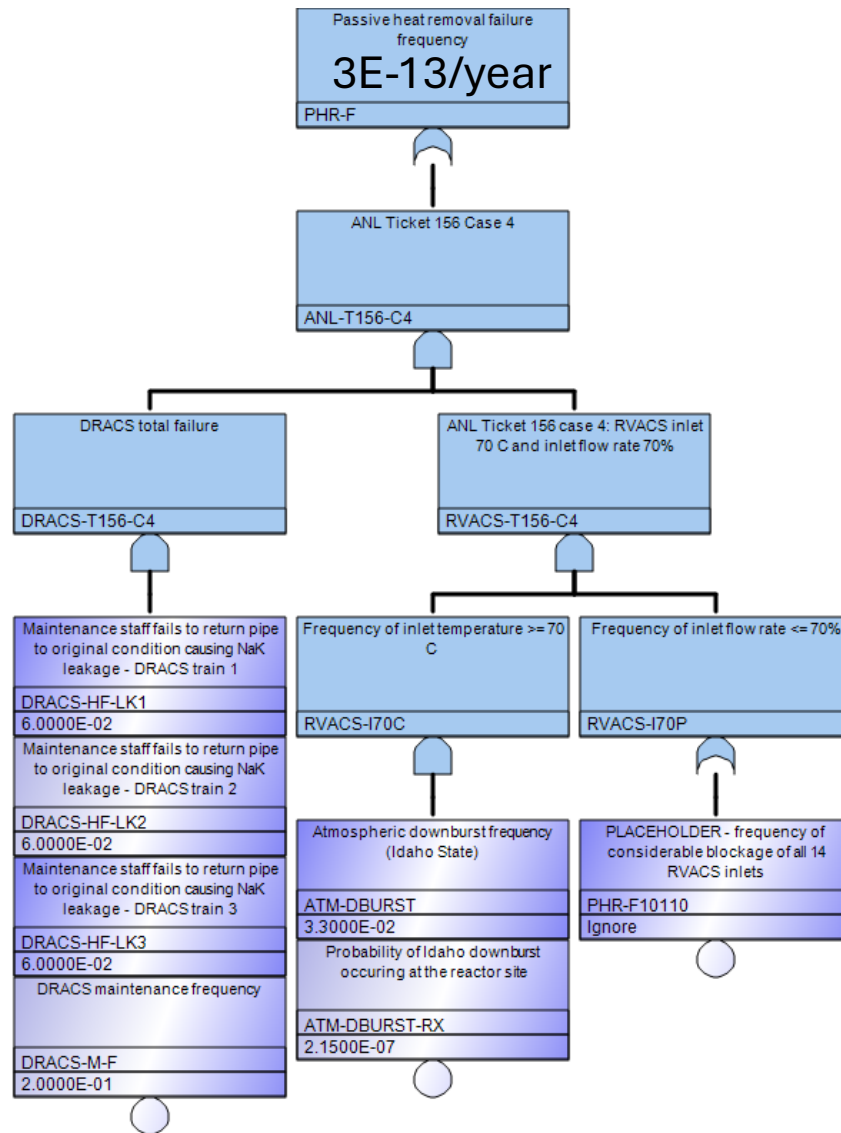
Notes:

- No fuel damage in cases 1 to 3.
- Fuel is assumed damaged in case 4. Cladding is exposed to 650 °C for 200 hours, to which Arrhenius equation predicts fuel damage. However, historical data shows eutectic formation happens only at temperature higher than 650 °C.

Margin to failure for Cases 1, 2, and 3.



Fault Tree for Case #4



- Failure of all 3 DRACS trains:
 - Simultaneous pipe break due to random failures $\rightarrow$ frequency is assumed trivial
 - Maintenance error, conservatively assuming latent defects activate simultaneously although maintenance is at different times.
- RVACS hot inlet temperature:
 - Ambient temperature > 70 C: improbable
 - Downburst event assuming Idaho site that blows hot exhaust air back into inlet
- Considerable blockage on all RVACS inlets due to insect swarms, leaves & cottonwood: Ignored
 - Leaves and cotton fluffs can be screened by requiring no such trees within OCA
 - Insect outbreaks frequency is low, and its impact can be prevented by cleaning inlets before clogging becomes excessive

Ambient Temperature Analysis

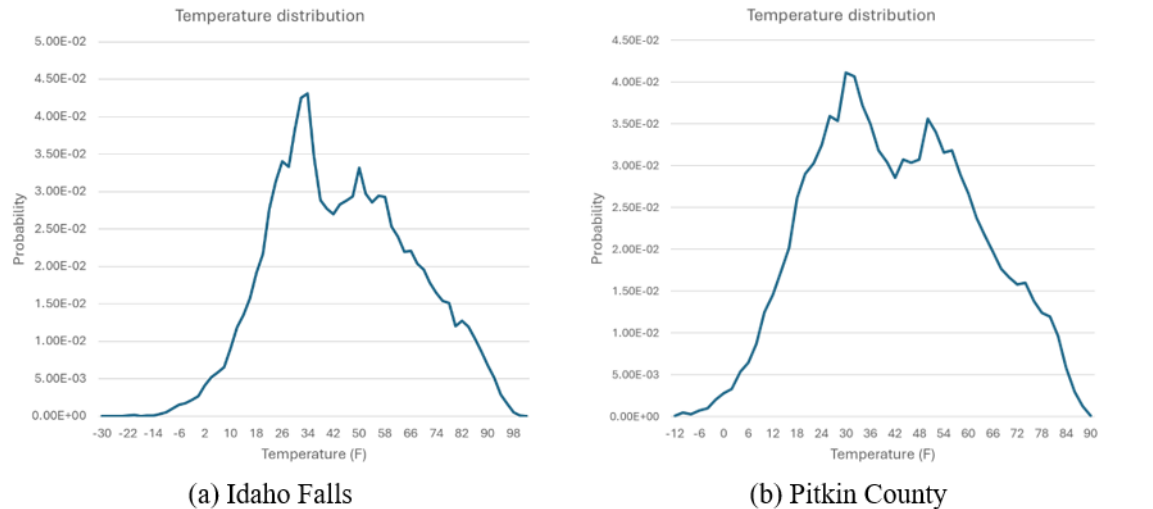


Figure F-7. Temperature distribution in two representative cold regions in the US from 2020 to 2025

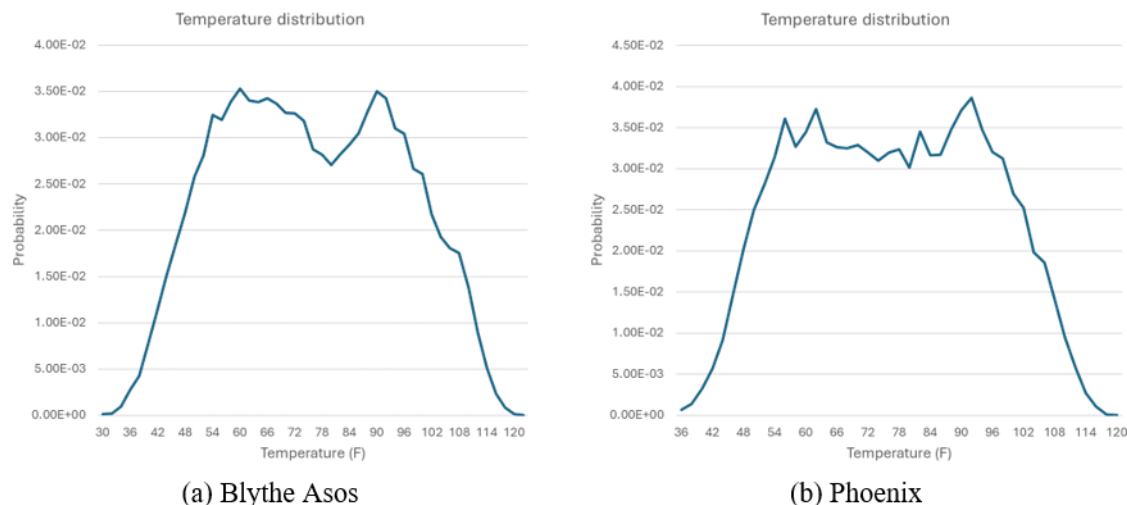


Figure F-8. Temperature distribution in two representative hot regions in the US from 2020 to 2025

- Annual frequency of hourly ambient temperature in Idaho Falls < NaK freezing point (9.3 deg F): 285/year
 - NaK uses double piping heated with heat-trace cables
 - Not a safety concern but performance, because reactor will not be started before NaK loop is thawed
- Annual frequency of ambient temperature in Idaho Falls > 158 deg F: 0/year
 - Highest ambient temperature recorded was 123 deg F at Blythe Asos, California
 - Wildfires: can be screened out by requiring no vegetation in reactor building's vicinity

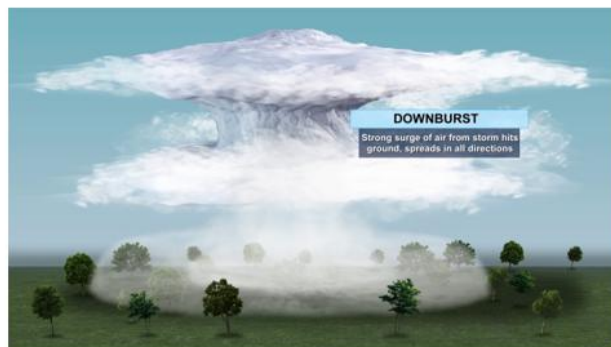
Downburst Analysis



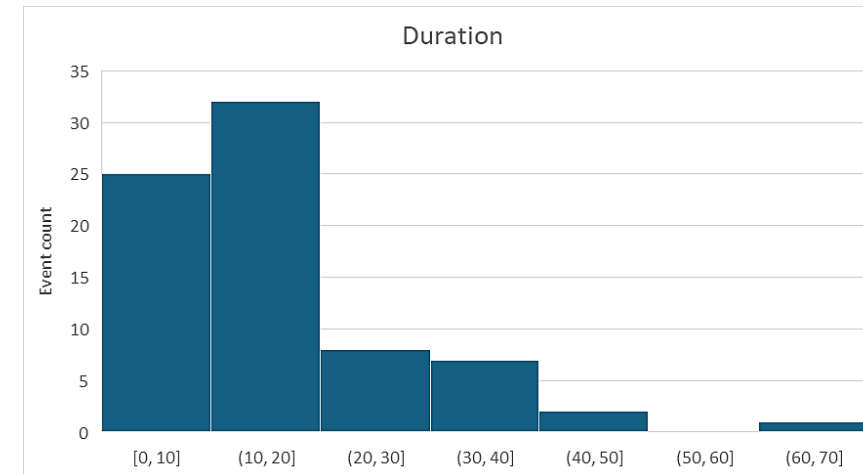
(a) initial stage of storm development



(b) Heavy rain and/or hail evaporating mid-air cooling the storm center



(c) The dense cold air falls rapidly as a downburst



Histogram of downburst duration in Idaho state from 1994 to 2023 (x-axis is in minutes).

- Long downbursts (an hour or more) that can impact RVACS: 0.033 event/year
- Assuming a uniform probability of downbursts across Idaho state, probability of downburst at ARC-100 Idaho site: ratio of OCA/Idaho = $2.15E-7$

Other Environmental Factors

- Heavy snow blocking RVACS inlets → does not happen concurrently with 70 °C inlet temperature
- Cottonwood fluffs or dead leaves clogging RVACS gratings → screened out by requiring no such trees nearby. Maintenance workers can also clear it easily before it gets too extensive.
- Insect outbreaks
 - Mormon crickets → Applicable to Idaho site. Severe outbreaks every 10 to 20 years
 - Grasshoppers → Applicable to Idaho site. Severe outbreaks every 8 to 10 years
 - Cicadas → Not applicable to Idaho site
 - Mayflies → Not applicable to Idaho site
- Insect outbreaks can be screened out due to low frequency, and ease of mitigation before they clog RVACS significantly.

Key Conclusions and Future Work

- PSA Conclusions per August 2026:
 - Used IDHEAS-ECA for HRA, including pre-initiating events in several IEs
 - Started self-assessment against ASME/ANS non-LWR PSA standard
 - Assessed failure of passive cooling systems based on 4 deterministic scenarios. Resulting frequency is trivial ($3E-13$ /year)
 - Internal events PSA is not finished yet
 - LPSD PSA has not started
 - Seismic PSA remains the largest risk contributor and is discussed in separate meetings
- Future Works
 - Continue self-assessment against ASME/ANS non-LWR PSA standard
 - Continue pre-initiator HRA in remaining internal events
 - Continue seismic PSA as more data becomes available

Backup Slides

Appendix A: PSA slides in 2025 NRC meeting as a reference (INL/MIS-25-84840)

PSA Presented to NRC in March 2024

- Tool: SAPHIRE (static) & EMRALD (dynamic)
- Event Trees:
 - Transient Overpower
 - Loss of Flow
 - Loss of Heat Sink
- Fault Trees:
 - Loss of flow initiator
 - Reactor Protection System
 - Passive Heat Removal
- End-state categories
 - No fuel damage (NFD)
 - Controlled Stable State (CSS)
 - Fuel damage – Low consequence (FD-LC)
 - Fuel damage – Medium consequence (FD-MC)
 - Fuel damage – High consequence (FD-HC)
- Common-cause failures: Alpha factors
- Human failure modeling: SPAR-H
- Importance measures:
 - Fussel-Vessely
 - Birnbaum
- Main control room fire analysis (skipped due to time limitation)

Key Results per March 2024

- End state frequencies:

Name	Point Estimate	Cut Set Count	Mean	Median	5th	95th
CSS	5.442E-11	261	4.596E-11	4.585E-11	4.208E-11	5.020E-11
FD-HC	1.519E-12	151	1.318E-12	1.315E-12	1.205E-12	1.442E-12
FD-LC	2.022E-13	8	1.645E-13	1.595E-13	9.546E-14	2.500E-13

- These frequencies are low because the PRA model was incomplete
- Importance measures suggested human failures and CCF events as more important relative to other events

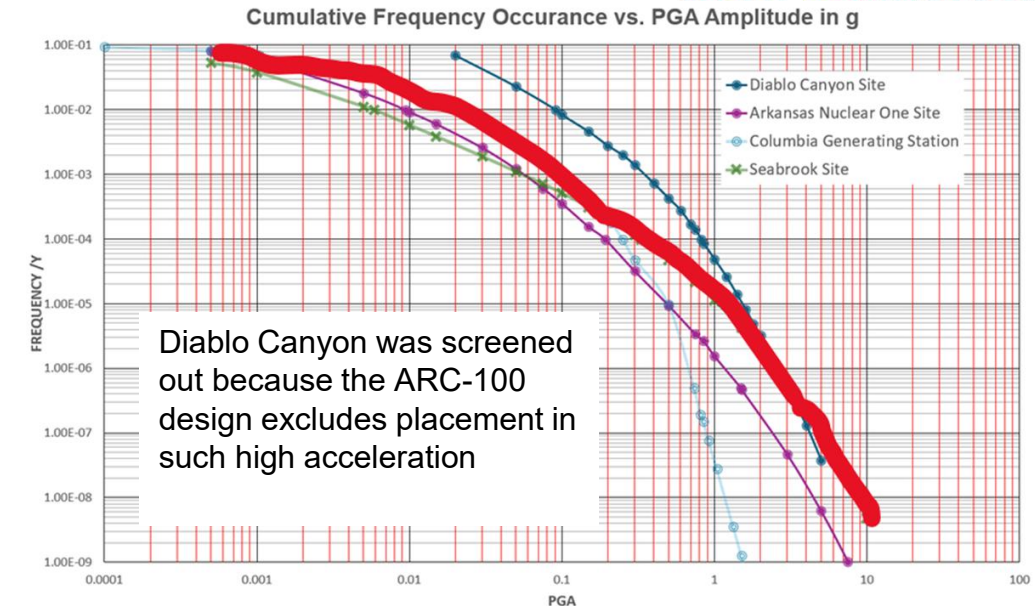
PSA Updates up to December 2024

- Seismic PSA (presented to NRC in November 2024)
- Fire PSA
- Loss of Heat Sink initiator fault tree
- Comparison of ARC-100 PSA to NRC SPAR Methodology

ARC-100 Seismic PRA Overview/Status



- Three sites were selected to represent the majority of the Continental US, and the bounding curve was used
- Six bins were chosen based on NEI 18-04 thresholds, the SDBE level of 0.5 PGA (Bin 3), and 1.5x the SDBE (Bin 4)
- Seismic SSCs were identified and HCLPF was calculated
- Spectral analysis results were used to determine the acceleration or dampening at the SSC's location within the reactor building
- Found that the 2-dimensional isolators were not adequate
 - The displacement exceeded the movement range of the isolators and upper bin results were only estimates
- Assuming unlimited movement range of the isolators, the point estimate of any size release of radioisotopes to the environment was **2.23E-5/y**. Seismic is bounding and requires improved (3-D) isolation after which new SA will inform the seismic PRA model.
- Still, the 2-D horizontally Isolated Reactor Building is capable of withstanding the SSE (0.5 PGA) without damage



Name	Point Estimate
Totals	2.24E-05
EQK-BND-PGA-BIN-1	9.84E-16
EQK-BND-PGA-BIN-2	1.43E-08
EQK-BND-PGA-BIN-3	3.81E-06
EQK-BND-PGA-BIN-4	8.30E-06
EQK-BND-PGA-BIN-5	9.73E-06
EQK-BND-PGA-BIN-6	5.55E-07

Summary of Fire PSA

- Follows NUREG/CR-6850 methodology
- Fire PSA is incomplete due to lack of detailed data in this conceptual engineering design phase.
- Completed tasks:
 - Task 1: Plant boundary & partitioning
 - Identified global boundary, fire areas and fire zones
 - Identified fire loading and severity in most fire partitions
 - Task 2: Fire PRA component selection
 - Identified affected internal events in the PSA model
 - Listed safe-shutdown-related SSCs & success criteria in each fire partition
 - Identified PSA initiators due to a fire in each partition, including automatic trip, manual trip, and breach of Limiting Conditions of Operations (LCO)
 - Identified equipment important to human response that may be unsafe to access and operate due to fires

Key Conclusions and Future Work

- PSA Conclusions per December 2024:
 - Seismic events are the main drivers of plant risk
 - Three-dimensional seismic isolation is suggested to reduce seismic risk
 - Risk from fire events is not quantified yet
 - For other internal events, human operator failure still has the highest importance measure followed by CCF events
 - ARC-100 PSA methodology includes the NRC SPAR methodology and other additions
- Ongoing / Future Works
 - PSA model improvements using latest engineering design
 - Seismic PSA modification using 3-D isolators
 - Internal and peer review of PSA work to the ASME/ANS RA-S-1.4-2021 Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants.