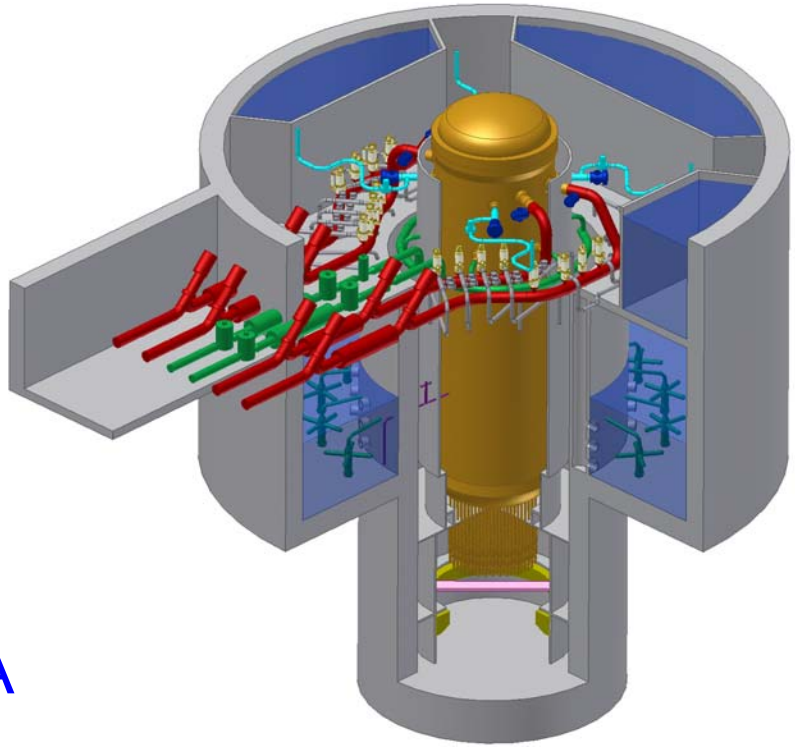
Treatment of Thermal-Hydraulic Uncertainties Associated with Passive Systems



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Thermal-Hydraulic Uncertainty

Passive systems have lower driving head than traditional systems

PRA success criteria are based on best-estimate calculations

$$\frac{\text{Flow Uncertainty}}{\text{Flow Rate}}$$ may not be negligible

Uncertainty analyses are performed to confirm robust success criteria

Approach To Resolution

MAAP 4.0.6 used to determine success criteria

- Confirm ESBWR MAAP model
- Compare to TRACG

Determine minimum success

- Gravity Driven Cooling System and Equalizing
- Depressurization Valves
- Passive Containment Coolers

Compare to PRA success criteria

Evaluate quantitative sensitivity to success criteria

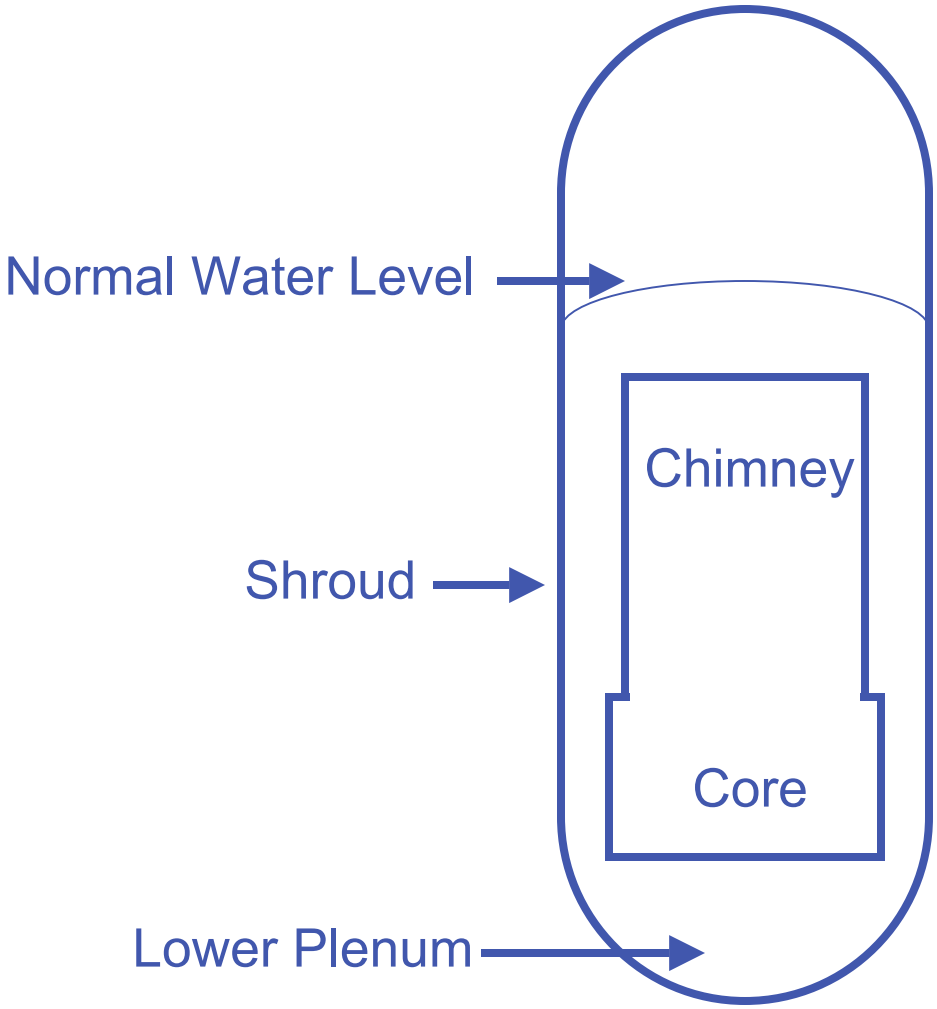
Confirm ESBWR MAAP Model

Updated using latest design information

Steady state cases used to confirm

- Initial water volume in RPV zones
- Feedwater and Main Steam flows
- Core inlet flow
- Core average void fraction
- Chimney exit void fraction

Major ESBWR Water Zones for MAAP



All zones within 2% of GE Weights and Volumes Calculation

Compare With TRACG

Two LOCA cases represent passive ECCS performance

- Main Steam Line Break with 1 GDCS valve failure
- GDCS Line Break with 1 GDCS valve failure

Benchmark with DCD Rev 3 cases

Short term and long term response evaluated

MSLB Short Term Comparison

MSLB – 1 GDC Valve Fails

MSLB ADS Delay – 1 GDC Valve Fails

Key parameters match within expectations

Level instrument modeled differently

- Accounts for most of difference
- MAAP starts ADS sooner
- Sensitivity shows no effect on results

Shroud configuration

- Only different when water above core

Some TRACG metrics not available in MAAP

- e.g. Collapsed water level in chimney

GDCS Break Short Term Comparison

GDCS – 1 GDC Valve Fails

Key parameters match within expectations

Level instrument not an issue

> ADS starts before flashing in shroud region

Long Term Comparison

MSLB Long Term – 1 DPV Fails

GDCS Long Term – 1 DPV Fails

Key parameters match within expectations
Containment pressure slightly lower in MAAP
TRACG pressure increases due to H2 buildup
Well away from ultimate pressure used for success criteria
Heat sinks in MAAP offset effectiveness of PCCS

Success Criteria T-H Sensitivities

Determined limiting Large LOCA

2 GDCS Valves, No Depressurization

RWCU / SDC suction line

Sensitivity parameters

- # GDCS valves
- # GDCS pools
- Break coefficient & location
- # Equalizing lines
- Natural circulation parameters

Results - LLOCA

	PRA	Minimum
GDCS Valves	2	< 1
GDCS Pools	2	1
Equ Valves	1	0
PCCS	4	< 2

Results - MLOCA

	PRA	Minimum
GDCS Valves	2	< 1
GDCS Pools	2	1
Equ Valves	1	0
PCCS	4	< 2
DPV	4	< 3

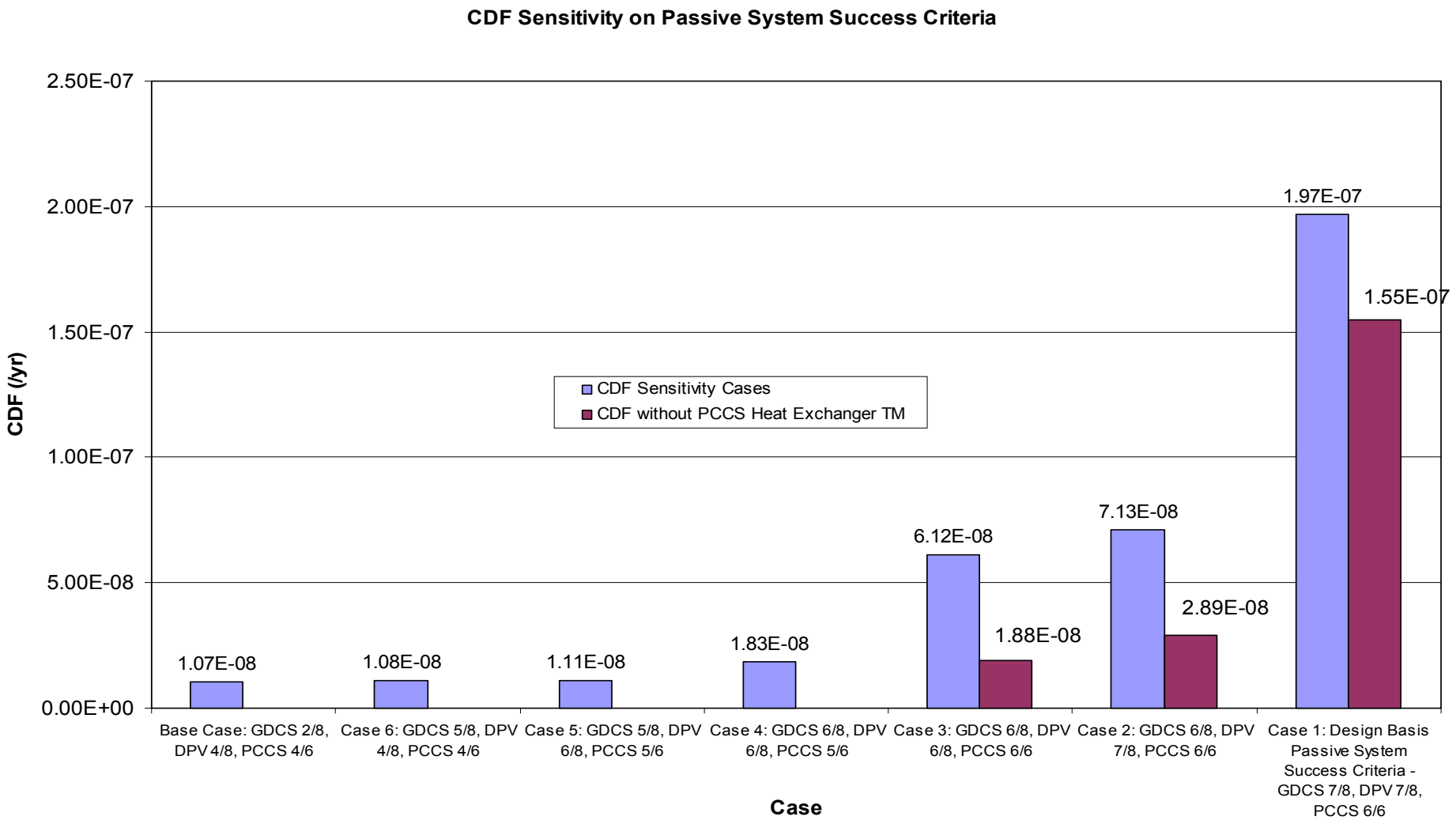
CDF Sensitivities

Adjusted success criteria in event trees

- GDCS valves
- DPV valves
- PCCS heat exchangers

Design basis criteria (single failure allowed)

Added redundancy until CDF reached baseline



CDF Sensitivity Results

GDCS success not significant until 6 of 8

PCCS success not significant until 6 of 6

- Test and maintenance assumption is key

DPV success not significant until 7 of 8

Any redundancy allows for acceptable CDF

Thermal-Hydraulic Conclusions

ESBWR success criteria is robust

Conservative with respect to T-H evaluations

PRA model is not sensitive to changes in success criteria as long as redundancy is maintained