

# ***Loss of Offsite Power Modeling***

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## ***LOOP/SBO Modeling Guidance Documents***

- Generally in compliance with “Treatment of Loss of Offsite Power (LOOP) in Probabilistic Risk Assessments: Technical Basis and Guidelines”, Draft EPRI report.
- NUREG/CR-6890, Volume 1 and 2. provides industry average initiator frequencies and recovery curves. (Data updated yearly and posted to NRC website.)
  - Plant centered, switchyard centered, grid related, weather related (extreme weather related for some plants) initiators and recovery curves.
  - One set of industry average frequencies and offsite power recovery curves for all plants.
  - One set of diesel recovery curves for all plants.

## ***LOOP/SBO Modeling Details***

- Initiating event frequency (per reactor critical year)
- Standardized event naming
  - Ex: OEP-XHE-XL-NR01HPC (Offsite power recovery)
  - Ex: EPS-XHE-XL-NR01H (Diesel recovery)
  - Ex: OEP-XHE-XX-NR02H0 (Convolution correction)
- Template data set includes all OEP and EPS recovery values for 0-24 hours (1 hour increments)

## ***LOOP/SBO Modeling Details – continued***

- Conditional LOOP.
  - Modeled using transfer from transient event trees. (TRANS, LOCHS, LOMFW, risk-insignificant xfrs commented out)
  - Modeled with fault tree logic in LOCA scenarios
- Switchyard components included (but not recoverable)
- Logic loop broken at power supply to ESW pumps
- SBO Sequences developed to full 24 hour mission (and extended logic commented out if no significant risk contribution found)

## ***LOOP/SBO Modeling Details – continued***

- Diesel mission time: 24 hours for all sequences.
- DG FTR probability is based on a two-part hazard curve.
  - ZT-DGN-FR-E, 0 to 1 hour,  $3.8E-3$
  - ZT-DGN-FR-L, 1 to 24 hours,  $1.0E-3/hr$
  - The parts are automatically summed using a SAPHIRE utility module.
- DG non-recovery probability is based on unplanned outage duration.  
(not included in convolution calcs)

## ***LOOP/SBO Modeling Details – continued***

- Convolution corrections available for up to 4FTR terms.
  - CCF is treated same as 1FTR term.
  - Standard recovery rule set is made plant-specific by macros at top of rule section.
  - Convolution correction is applied by recovery rules.
  - Models transitioning to use of automated application of convolution corrections
    - Benefits include automatic generation of new convolution factors each time DG FTR data is updated

# SAPHIRE Macro Example

- Project-level recovery rule macros for applying convolution correction.

```

=====
| Convolution correction rules.
|
| Define all possible combinations of fail-to-run event
|
zCCF = EPS-DGN-CF-RUN ;
z1FTR = EPS-DGN-FR-DGA +
      EPS-DGN-FR-DGB +
      EPS-DGN-FR-DGC +
      EPS-DGN-FR-DGD ;
z2FTR = EPS-DGN-FR-DGA * EPS-DGN-FR-DGB +
      EPS-DGN-FR-DGA * EPS-DGN-FR-DGC +
      EPS-DGN-FR-DGA * EPS-DGN-FR-DGD +
      EPS-DGN-FR-DGB * EPS-DGN-FR-DGC +
      EPS-DGN-FR-DGB * EPS-DGN-FR-DGD +
      EPS-DGN-FR-DGC * EPS-DGN-FR-DGD ;
z3FTR = EPS-DGN-FR-DGA * EPS-DGN-FR-DGB * EPS-DGN-FR-DGC +
      EPS-DGN-FR-DGA * EPS-DGN-FR-DGB * EPS-DGN-FR-DGD +
      EPS-DGN-FR-DGA * EPS-DGN-FR-DGC * EPS-DGN-FR-DGD +
      EPS-DGN-FR-DGB * EPS-DGN-FR-DGC * EPS-DGN-FR-DGD ;
z4FTR = EPS-DGN-FR-DGA * EPS-DGN-FR-DGB * EPS-DGN-FR-DGC * EPS-DGN-FR-DGD;

```

# ***SAPHIRE Recovery Rule Application***

- Project-level recovery rule for application of convolution correction.

|-----  
| Frequency weighted average

```
if      (zCCF) * OEP-XHE-XL-NR01H then
  AddEvent = OEP-XHE-XX-NR01H0;
elseif (z4FTR) * OEP-XHE-XL-NR01H then
  AddEvent = OEP-XHE-XX-NR01H4;
elseif (z3FTR) * OEP-XHE-XL-NR01H then
  AddEvent = OEP-XHE-XX-NR01H3;
elseif (z2FTR) * OEP-XHE-XL-NR01H then
  AddEvent = OEP-XHE-XX-NR01H2;
elseif (z1FTR) * OEP-XHE-XL-NR01H then
  AddEvent = OEP-XHE-XX-NR01H1;
endif
```



# SAPHIRE Recovery Rule Application – Automated Interface

Convolution Event Mapping

(Model Type / Phase) **RANDOM** / CD

### Loop Recovery Types (LRT)

Name	Code
Plant Centered	PC
Switchyard	SC
Grid Related	GR
Weather Related	WR
Freq. Weight Avg.	

Add Delete

### Failure Times (FT)

Minute Add

Time divisions
30M
01H
90M
02H
03H
04H
05H

Delete

### Failure Combinations (FC)

N of M	Code	Basic Event
1	1	A EPS-DGN-FR-DGA
2	2	B EPS-DGN-FR-DGB
3	3	C EPS-DGN-FR-DGC
4	4	D EPS-DGN-FR-DGD

Add Delete

### Recovery Event Mapping

Name Prefix: OEP-XHE-XL-NI + Map Type: FT + LRT + Check Events

	Name	Description
1	OEP-XHE-XL-NR30MPC	OPERATOR FAILS TO RECOVER
2	OEP-XHE-XL-NR30MSC	OPERATOR FAILS TO RECOVER
3	OEP-XHE-XL-NR30MGR	OPERATOR FAILS TO RECOVER
4	OEP-XHE-XL-NR30MWR	OPERATOR FAILS TO RECOVER
5	OEP-XHE-XL-NR30M	OPERATOR FAILS TO RECOVER
6	OEP-XHE-XL-NR01HPC	OPERATOR FAILS TO RECOVER
7	OEP-XHE-XL-NR01HSC	OPERATOR FAILS TO RECOVER
8	OEP-XHE-XL-NR01HGR	OPERATOR FAILS TO RECOVER
9	OEP-XHE-XL-NR01HWR	OPERATOR FAILS TO RECOVER
10	OEP-XHE-XL-NR01H	OPERATOR FAILS TO RECOVER

Set As Default Load Defaults

### Convolution Event Mapping

Name Prefix: OEP-XHE-XX-N + Map Type: FT + LRT + FC + Generate Names

	Name
642	OEP-XHE-XX-NR24HWR1
643	OEP-XHE-XX-NR24HWR2
644	OEP-XHE-XX-NR24HWR3
645	OEP-XHE-XX-NR24HWR4
646	OEP-XHE-XX-NR24H0
647	OEP-XHE-XX-NR24H1
648	OEP-XHE-XX-NR24H2
649	OEP-XHE-XX-NR24H3
650	OEP-XHE-XX-NR24H4

OK Cancel

## ***Key PWR Operator Actions***

- Key operator actions to extend SBO coping time.
  - AFW TDP control beyond battery lifetime
  - CST refill
  - Manual depressurization beyond battery lifetime
  - Alignment of power independent injection source
- AC power recovery following battery depletion.
  - Typically not allowed in SPAR model
  - Remains a key modeling uncertainty

## ***Key BWR timing limitations***

- RCIC SBO limitations (Plant X PSA).
  - Exhaust Pressure (about 10 hours)
  - Suction Temperature (about 11 hours)
  - Pressure Suppression Curve (about 17 hours)
  - HCTL (about 14 hours)
  - High Drywell Temperature (about 20 hours)
  - High Area Temperature ( > 12 hours)
  - CST inventory (very plant specific)
  - Battery Depletion (very plant specific)

## ***Key BWR timing limitations - continued***

- HPCI SBO limitations (Plant X PSA)
  - Exhaust Pressure (N/A)
  - Suction Temperature (8 hours)
  - Pressure Suppression Curve (14 hours)
  - HCTL (11 hours)
  - High Drywell Temperature (17 hours)
  - Area Temperature (>12 hours)
  - CST inventory (very plant specific)
  - Battery depletion (very plant specific)
- 12 hours maximum credit for HPCI/RCIC in SPAR SBO models
  - based on NUREG-1953 ‘Confirmatory Thermal-Hydraulic Analysis to Support Specific Success Criteria in the Standardized Plant Analysis Risk Models—Surry and Peach Bottom’

## ***Key BWR Operator Actions***

- Key operator actions to extend SBO coping time.
  - DC load shedding
  - RCIC control beyond battery lifetime
  - HPI suction maintained on CST
  - CST refill
  - Manual depressurization beyond battery lifetime
  - Firewater alignment or alternate engine-driven source
  - Containment venting
- AC power recovery following battery depletion.
  - Typically not allowed in SPAR model
  - Remains a key modeling uncertainty