

# Precursor Screening Analysis - Reject

Accident Sequence Precursor Program – Office of Nuclear Regulatory Research

<b>Brunswick Steam Electric Plant, Unit 1</b>		The operators found the High pressure coolant injection (HPCI) system to be inoperable during a weekly TS-test due to a failure of the auxiliary oil pump.	
<b>Event Date:</b> 02/12/2015	<b>LER:</b> 325-2015-001-00	<b>IR:</b> 05000325/2015007	
<b>Plant Type:</b> GE, BWR-4 plant with Mark I containment			
<b>Plant Operating Mode (Reactor Power Level):</b> Mode 1 (100% Reactor Power)			
<b>Analyst:</b> Erulappa Chelliah	<b>Reviewer:</b> Christopher Hunter	<b>Contributors:</b> N/A	<b>BC Approved Date:</b> 4/ /2016

## Event Description.

At 1336 Eastern Standard Time, on February 12, 2015, the operators declared the High Pressure Coolant Injection (HPCI) System at Brunswick Steam Electric Plant (BSEP) Unit 1 to be inoperable due to an as-found failure of the HPCI auxiliary oil (AO) Pump.

During a technical specifications (TS)-required testing of the HPCI system, the operators started the HPCI-AO pump. The operators found a failure of the AO pump, including a HPCI system failure to start on test-demand. During the test, the HPCI system experienced a loss of discharge oil pressure.

The HPCI-AO pump provides hydraulic pressure required to open the HPCI-turbine stop valve and the HPCI turbine control valve during initial HPCI startup. A failure of the HPCI-AO pump prevents the HPCI system from performing its design safety function.

The HPCI system is an emergency core cooling system at BSEP Unit 1. The licensee reported this degraded condition, in a licensee event report (LER), in accordance with 10 CFR Part 50.73(a)(2)(v)(D), as an event or condition that could have prevented the fulfillment of the safety function of a system to mitigate an accident. (Reference-1)

After the as-found failure of the HPCI system, the operators realized that the HPCI-AO pump did not fail, and therefore, the HPCI system was successfully started during the last TS-test (2/5/2015). Then, the operators safety-determined that, during the current TS-test, on 2/12/2015, the HPCI system failed to start due to a pre-existing failure of the HPCI-AO pump.

Therefore, the operators found the HPCI-system to be inoperable due to its unavailability at standby position for a condition period of 15-days (one test interval of 7 days + 8 days to provide a corrective action to fix the failed HPCI-AO pump). The licensee found a specific degraded condition period of the HPCI train to be from 2/5/2015 to 2/20/2015. Unit 1 was operating at power mode during this 15-days period.

## Failure causes:

The licensee found the failure cause of the HPCI system inoperability to be a faulty magnetic motor contactor coil within the HPCI-turbine, auxiliary oil pump motor contactor. The licensee also determined a failure of the coil to be an equipment failure. Then, the licensee replaced the failed coil. The operators returned the HPCI system to a functional state, on February 20, 2015.

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Inspection findings:

Region II inspectors reviewed the LER information and other related information. Region II closed the LER [Reference-2].

Degraded condition-related failures:

The HPCI-AO pump was unavailable for a condition period of 15-days (02/05/2015 thru 02/20/2015).

**Analysis Type.** RES\DRA\PRB analyst conducted one condition risk analysis case [CRA-1 analysis case] in estimating increase in core damage probability [ICDP] due to an as-found inoperability of the HPCI system.

**Analysis Rules.** The ASP Program uses Significance Determination Process (SDP) result for degraded conditions when available. However, the ASP Program performs independent analyses for events where there are degraded conditions that exist simultaneously (i.e., are windowed within the same timeframe) when not explicitly assessed under the SDP. As such, an ASP analysis was performed for the conditions described in the referenced LERs.

**Key Modeling Assumptions.**

The CRA-1 analysis case found the inoperable condition-period of 15 days to be greater than the allowed outage time [AOT] of 14-days by the licensed TS. The CRA-1 analysis case estimated a condition period of 15 days, based on as-found 7-days inoperability period of the HPCI system and a subsequent 8-days period to fix the failed HPCI-AO pump.

1. BSEP Unit 1 did not automatically scram during the specific condition period [02/05/2015 thru 02/20/2015]. Also, the operators did not manually scram the Unit 1 reactor at power during this specific period of the HPCI system inoperability.
2. Neither the analyst nor the reviewer of RES\DRA\PRB identified any overlapping conditions and/or simultaneous failure conditions of other safety systems (other than the HPCI system) during the specific condition period of 15-days period.
3. The licensee would not have repaired or recovered the failed HPCI-AO pump in less than an 8-days period to mitigate a postulated transient or a LOCA event.

**Logic model-changes to recent SPAR model of BSEP Unit 1.**

Idaho National Laboratory published a recent plant probabilistic failures-model for Brunswick, Unit 1 [SPAR-Model No. 8.2, dated 07/29/2009].

Three fault trees of the HPCI system were reviewed with respect to the published HPCI system reliability study. CRA-1 analysis case found this SPAR model version to be adequate to conduct a condition risk analysis of the as-found HPCI inoperability (LER-325-2015-001).

Specifically, a new basic event, HE-HPCI-15D (A HOUSE EVENT TO TRIGEER A START OF INOPERABILITY), was created and was added to the "top OR gate" of the following fault trees:

- FAULT TREE, HCI
- FAULT TREE, HC1
- FAULT TREE, HCI-B

Baseline value of new basic event, HE-HPCI-15D, was set to FALSE.

**Basic Event Probability-changes.**

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Basic event, HE-HPCI-15D was set to TRUE trigger the start of the HPCI-inoperability condition for a period of 15-days. A degraded condition duration of 15 days was input to SAPHIRE-8 condition analysis option.

### **Rejection basis.**

Analysis documented the results of a CRA of the HPCI train inoperability in Attachment-1 to this report:

Analysis estimated Increase in core damage probability of  $6.36E-8$  due to an as-found inoperable condition of the HPCI-AO pump for a specific period of 15-days (02/05/2015 thru 02/20/2015).

- Analysis found contributing dominant sequences due to degraded condition-affected sequences of the grid-related loss of offsite power (LOOPGR) event tree.
- Analysis estimated an increase in core damage probability of about  $2.66E-8$  due to the LOOPGR event tree.
- Analysis found a condition-affected dominant sequence of the LOOPGR event tree, LOOPGR-25. Analysis estimated an increase in core damage probability of about  $2.44E-8$  due to dominant sequence, LOOPGR-25.

In summary,

1. Under the CRA, the point estimate for the increase in core damage probability is  $6.36 \times 10^{-8}$  due to an as-found inoperable condition of the HPCI AO pump at power mode of the Brunswick Unit 1 reactor.

This point estimates is below  $1 \times 10^{-6}$  and therefore, the events described in LER-325-2015-001 does not meet ASP Program criteria to be defined as a precursor.

Therefore, the licensee-found inoperable condition of the HPCI system at Brunswick Steam Electric Plant Unit 1, on 02/12/2015, would not have resulted in a precursor event during the power operation-period of 15 days

## **REFERENCES**

1. Brunswick Steam Electric Plant Unit 1, "High Pressure Coolant Injection (HPCI) System Inoperable due to Auxiliary Oil Pump Failure – Duke Energy, LER-325-2015-001-00, Event Date of February 12, 2015," dated April 10, 2015. ML15113A347.
2. U. S. Nuclear Regulatory Commission, Brunswick Steam Electric Plant, Unit 1 – NRC PROBLEM IDENTIFICATION AND RESOLUTION Inspection report, 05000325/2015007, DATED JULY 29, 2015.

ATTACHMENT-1: SAPPHIRE8 ANALYSIS REPORT- BRUNSWICK STEAM ELECTROPLANT, UNIT 1, CONDITION RISK ANALYSIS OF LER-325-2015-001-00

## Event Tree Dominant Results

Only items contributing at least 1.0% to the total CCDP are displayed.

<u>EVENT TREE</u>	<u>CCDP</u>	<u>CDP</u>	<u>Δ CDP</u>	<u>DESCRIPTION</u>
LOOPGR	6.60E-8	3.94E-8	2.66E-8	BRUNSWICK 1 LOSS OF OFFSITE POWER - GRID RELATED
LOIA	3.34E-8	1.49E-8	1.85E-8	BRUNSWICK 1 LOSS OF INSTRUMENT AIR SYSTEM
LOOPWR	2.15E-8	1.45E-8	7.04E-9	BRUNSWICK 1 LOSS OF OFFSITE POWER - WEATHER
LOOPSC	2.20E-8	1.59E-8	6.03E-9	BRUNSWICK 1 LOSS OF OFFSITE POWER - SWITCH YARD
LODC1B2	1.05E-8	8.53E-9	1.96E-9	BRUNSWICK 1 LOSS OF DC BUS 1B2
LOAC-E1	2.93E-9	2.24E-9	6.88E-10	BRUNSWICK 1 LOSS OF AC BUS E1
<b>Total</b>	<b>3.12E-7</b>	<b>2.48E-7</b>	<b>6.36E-8</b>	

## Dominant Sequence Results

Only items contributing at least 1.0% to the total CCDP are displayed.

<u>EVENT TREE</u>	<u>SEQUENCE</u>	<u>CCDP</u>	<u>CDP</u>	<u>Δ CDP</u>	<u>FLAGSET</u>	<u>DESCRIPTION</u>
LOOPGR	25	2.65E-8	2.07E-9	2.44E-8	ETF-LOOPGR	/RPS, /EPS, /SRV, HPI, DEP
LOIA	45	1.98E-8	1.55E-9	1.83E-8	ETF-LOIA	/RPS, /SRV-O, /SRV, HPI, DEP
LODC1B	32	1.47E-8	1.14E-9	1.35E-8	ETF-LODC1B	/RPS, PCS, /SRV-O, /SRV, HPI, /DEP, CDS, /LPI, SPC, SDC, CSS, PCSR, /CVS, LI
LOOPWR	25	7.17E-9	5.61E-10	6.61E-9	ETF-LOOPWR	/RPS, /EPS, /SRV, HPI, DEP
LOOPSC	25	5.84E-9	4.81E-10	5.36E-9	ETF-LOOPSC	/RPS, /EPS, /SRV, HPI, DEP
LODC1B2	32	3.53E-9	2.69E-10	3.27E-9	ETF-LODC1B2	/RPS, PCS, /SRV-O, /SRV, HPI, /DEP, CDS, /LPI, SPC, SDC, CSS, PCSR, /CVS, LI
LOOPGR	28-35	3.08E-9	2.08E-10	2.87E-9	ETF-SBOGR	/RPS, EPS, /SRV, /RPSL, RCI-B, HCI-B, OPR-30M, DGR-30M
LODC1B	40	5.41E-9	3.06E-9	2.35E-9	ETF-LODC1B	/RPS, PCS, /SRV-O, /SRV, HPI, /DEP, CDS, LPI, VA
LODC1B2	40	5.12E-9	3.03E-9	2.08E-9	ETF-LODC1B2	/RPS, PCS, /SRV-O, /SRV, HPI, /DEP, CDS, LPI, VA
LOOPWR	28-35	7.85E-10	4.21E-11	7.43E-10	ETF-SBOWR	/RPS, EPS, /SRV, /RPSL, RCI-B, HCI-B, OPR-30M, DGR-30M
LODC1B	41	1.43E-9	7.27E-10	6.99E-10	ETF-LODC1B	/RPS, PCS, /SRV-O, /SRV, HPI, DEP
LODC1B2	41	1.39E-9	6.92E-10	6.97E-10	ETF-LODC1B2	/RPS, PCS, /SRV-O, /SRV, HPI, DEP
<b>Total</b>		<b>3.12E-7</b>	<b>2.48E-7</b>	<b>6.36E-8</b>		

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## Referenced Fault Trees

<b>Fault Tree</b>	<b>Description</b>
CDS	CONDENSATE
CSS	CONTAINMENT SPRAY
DEP	MANUAL REACTOR DEPRESS
DGR-30M	DIESEL GENERATOR RECOVERY IN 30 MINS
EPS	EMERGENCY POWER
HCI-B	HPCI-SBO
HPI	HIGH PRESSURE INJECTION
LI	LONG-TERM LOW PRESS INJECTION
LPI	LOW PRESS COOLANT INJECTION (LCS or LPCI)
OPR-30M	OFFSITE POWER RECOVERY IN 30 MINS
PCS	POWER CONVERSION SYSTEM
PCSR	POWER CONVERSION SYSTEM RECOVERY
RCI-B	RCIC-SBO
SDC	SHUTDOWN COOLING
SPC	SUPPRESSION POOL COOLING
VA	ALTERNATE LOW PRESS INJECTION

### Cut Set Report - LOOPGR 25

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		6.44E-7	100	Displaying 43 Cut Sets. (43 Original)
1	C	3.96E-7	61.49	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-TDP-FR-TRAIN
2	C	1.09E-7	16.98	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-TDP-TM-TRAIN
3	C	6.48E-8	10.07	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-TDP-FS-TRAIN
4	C	2.99E-8	4.65	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
5	C	1.99E-8	3.09	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
6	C	9.98E-9	1.55	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-XHE-XO-ERROR
7	C	9.61E-9	1.49	IE-LOOPGR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITEGR,RCI-MOV-CC-F013

### Cut Set Report - LOIA 45

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		4.83E-7	100	Displaying 35 Cut Sets. (35 Original)
1	C	2.97E-7	61.52	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-TDP-FR-TRAIN
2	C	8.20E-8	16.98	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-TDP-TM-TRAIN
3	C	4.86E-8	10.07	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-TDP-FS-TRAIN
4	C	2.25E-8	4.65	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
5	C	1.49E-8	3.09	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
6	C	7.49E-9	1.55	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-XHE-XO-ERROR
7	C	7.21E-9	1.49	IE-LOIA,ADS-XHE-XE-ADSBT,RCI-MOV-CC-F013

### Cut Set Report - LODC1B 32

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		3.57E-7	100	Displaying 65 Cut Sets. (65 Original)
1	C	2.44E-7	68.36	IE-TDC1B,DCP-XHE-XA-ALTDC1,NSW-MDP-FC-BRUN,NSW-MDP-TM-1A,PCS-XHE-XL-LODC1B
2	C	4.34E-8	12.16	IE-TDC1B,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B,RHR-SYS-TM-A
3	C	1.77E-8	4.97	IE-TDC1B,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B,RHR-MOV-CC-F007A

#	CASES	PROB/FREQ	TOTAL%	CUT SET
4	C	1.75E-8	4.91	IE-TDC1B,DCP-XHE-XA-ALTDC1,NSW-AOV-CC-V129,PCS-XHE-XL-LODC1B
5	C	1.25E-8	3.52	IE-TDC1B,DCP-XHE-XA-ALTDC1,NSW-MDP-FC-BRUN,NSW-MDP-FS-1A,PCS-XHE-XL-LODC1B
6	C	8.87E-9	2.49	IE-TDC1B,DCP-XHE-XA-ALTDC1,NSW-MDP-FC-BRUN,NSW-MOV-CC-1SWV19,PCS-XHE-XL-LODC1B

#### Cut Set Report - LOOPWR 25

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		1.74E-7	100	Displaying 27 Cut Sets. (27 Original)
1	C	1.07E-7	61.50	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-TDP-FR-TRAIN
2	C	2.96E-8	16.98	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-TDP-TM-TRAIN
3	C	1.76E-8	10.07	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-TDP-FS-TRAIN
4	C	8.12E-9	4.65	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
5	C	5.39E-9	3.09	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
6	C	2.71E-9	1.55	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-XHE-XO-ERROR
7	C	2.61E-9	1.49	IE-LOOPWR,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITWR,RCI-MOV-CC-F013

#### Cut Set Report - LOOPSC 25

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		1.42E-7	100	Displaying 35 Cut Sets. (35 Original)
1	C	8.70E-8	61.20	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-TDP-FR-TRAIN
2	C	2.40E-8	16.90	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-TDP-TM-TRAIN
3	C	1.42E-8	10.02	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-TDP-FS-TRAIN
4	C	6.58E-9	4.63	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
5	C	4.37E-9	3.07	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-MOV-FC-XFER,RCI-XHE-XL-XFER
6	C	2.19E-9	1.54	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-XHE-XO-ERROR
7	C	2.11E-9	1.49	IE-LOOPSC,ADS-XHE-XE-ADSBT,OEP-VCF-LP-SITESC,RCI-MOV-CC-F013

#### Cut Set Report - LODC1B2 32

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		8.60E-8	100	Displaying 35 Cut Sets. (35 Original)
1	C	4.34E-8	50.45	IE-TDC1B2,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B2,RHR-SYS-TM-A
2	C	1.77E-8	20.63	IE-TDC1B2,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B2,RHR-MOV-CC-F007A
3	C	1.75E-8	20.37	IE-TDC1B2,DCP-XHE-XA-ALTDC1,NSW-AOV-CC-V129,PCS-XHE-XL-LODC1B2
4	C	1.77E-9	2.06	IE-TDC1B2,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B2,RHR-MOV-OO-F048A,RHR-XHE-XM-NPSH
5	C	1.77E-9	2.06	IE-TDC1B2,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B2,RHR-XHE-XM-NPSH,RSW-MOV-CC-F068A
6	C	9.21E-10	1.07	IE-TDC1B2,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B2,RHR-XHE-XM-ERROR,RHR-XHE-XM-NPSH
7	C	9.02E-10	1.05	IE-TDC1B2,DCP-XHE-XA-ALTDC1,PCS-XHE-XL-LODC1B2,RHR-STR-PG-S1

**Cut Set Report - LOOPGR 28-35**

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		7.49E-8	100	Displaying 162 Cut Sets. (162 Original)
1	C	1.86E-8	24.82	IE-LOOPGR,EPS-DGN-CF-RUN4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,OEP-XHE-XX-NR30MGR0,RCI-TDP-FR-TRAIN
2	C	1.41E-8	18.83	IE-LOOPGR,EPS-XHE-XL-NR30M,NSW-CKV-CF-EDGS,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-FR-TRAIN
3	C	5.14E-9	6.85	IE-LOOPGR,EPS-DGN-CF-RUN4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,OEP-XHE-XX-NR30MGR0,RCI-TDP-TM-TRAIN
4	C	4.69E-9	6.26	IE-LOOPGR,EPS-FAN-CF-RUN4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-FR-TRAIN
5	C	3.90E-9	5.20	IE-LOOPGR,EPS-XHE-XL-NR30M,NSW-CKV-CF-EDGS,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-TM-TRAIN
6	C	3.05E-9	4.06	IE-LOOPGR,EPS-DGN-CF-RUN4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,OEP-XHE-XX-NR30MGR0,RCI-TDP-FS-TRAIN
7	C	2.31E-9	3.08	IE-LOOPGR,EPS-XHE-XL-NR30M,NSW-CKV-CF-EDGS,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-FS-TRAIN
8	C	2.19E-9	2.93	IE-LOOPGR,ACP-CRB-CC-E1,ACP-CRB-CC-E2,EPS-XHE-XL-NR30M,OEP-XHE-XL-NR30MGR,RCI-TDP-FR-TRAIN
9	C	2.00E-9	2.67	IE-LOOPGR,EPS-SEQ-CF-DGS,EPS-XHE-XL-NR30M,EPS-XHE-XL-SEQ,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-FR-TRAIN
10	C	1.49E-9	1.99	IE-LOOPGR,EPS-DGN-CF-START4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-FR-TRAIN
11	C	1.41E-9	1.88	IE-LOOPGR,EPS-DGN-CF-RUN4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,OEP-XHE-XX-NR30MGR0,RCI-RESTART,RCI-TDP-FS-RSTRT,RCI-XHE-XL-RSTRT
12	C	1.29E-9	1.73	IE-LOOPGR,EPS-FAN-CF-RUN4,EPS-XHE-XL-NR30M,OEP-VCF-LP-SITEGR,OEP-XHE-XL-NR30MGR,RCI-TDP-TM-TRAIN



#	CASES	PROB/FREQ	TOTAL%	CUT SET
13	C	1.07E-9	1.42	IE-LOOPGR, EPS-XHE-XL-NR30M, NSW-CKV-CF-EDGS, OEP-VCF-LP-SITEGR, OEP-XHE-XL-NR30MGR, RCI-RESTART, RCI-TDP-FS-RSTRT, RCI-XHE-XL-RSTRT
14	C	9.55E-10	1.27	IE-LOOPGR, EPS-FAN-CF-START4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEGR, OEP-XHE-XL-NR30MGR, RCI-TDP-FR-TRAIN
15	C	7.68E-10	1.02	IE-LOOPGR, EPS-FAN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEGR, OEP-XHE-XL-NR30MGR, RCI-TDP-FS-TRAIN

#### Cut Set Report - LODC1B 40

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		1.32E-7	100	Displaying 96 Cut Sets. (96 Original)
1	C	4.41E-8	33.47	IE-TDC1B, ACP-CRB-CC-E1, DCP-XHE-XA-ALTDC1
2	C	3.13E-8	23.78	IE-TDC1B, DCP-XHE-XA-ALTDC1, LCS-ICC-FC-N031C
3	C	3.13E-8	23.78	IE-TDC1B, DCP-XHE-XA-ALTDC1, LCS-ICC-FC-N031A
4	C	4.09E-9	3.10	IE-TDC1B, ACP-BAC-LP-E1, CSW-MDP-FC-CSTBY
5	C	2.10E-9	1.59	IE-TDC1B, DCP-XHE-XA-ALTDC1, EPS-DGN-FR-DG1, OPR-XHE-XM-ALTUNITXC
6	C	1.74E-9	1.32	IE-TDC1B, DCP-XHE-XA-ALTDC1, LCS-MDP-TM-C001A, NSW-MDP-FC-BRUN, NSW-MDP-TM-1A
7	C	1.65E-9	1.25	IE-TDC1B, DCP-XHE-XA-ALTDC1, LCS-ICC-HI-N031ABCD

#### Cut Set Report - LODC1B2 40

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		1.24E-7	100	Displaying 73 Cut Sets. (73 Original)
1	C	4.41E-8	35.40	IE-TDC1B2, ACP-CRB-CC-E1, DCP-XHE-XA-ALTDC1
2	C	3.13E-8	25.16	IE-TDC1B2, DCP-XHE-XA-ALTDC1, LCS-ICC-FC-N031A
3	C	3.13E-8	25.16	IE-TDC1B2, DCP-XHE-XA-ALTDC1, LCS-ICC-FC-N031C
4	C	2.10E-9	1.68	IE-TDC1B2, DCP-XHE-XA-ALTDC1, EPS-DGN-FR-DG1, OPR-XHE-XM-ALTUNITXC
5	C	1.65E-9	1.32	IE-TDC1B2, DCP-XHE-XA-ALTDC1, LCS-ICC-HI-N031ABCD
6	C	1.25E-9	1.01	IE-TDC1B2, ACP-CRB-OO-AG0, DCP-XHE-XA-ALTDC1, EPS-DGN-FR-DG1
7	C	1.25E-9	1.01	IE-TDC1B2, ACP-CRB-OO-AJ5, DCP-XHE-XA-ALTDC1, EPS-DGN-FR-DG1

#### Cut Set Report - LOOPWR 28-35

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		1.91E-8	100	Displaying 92 Cut Sets. (92 Original)
1	C	4.65E-9	24.34	IE-LOOPWR, EPS-DGN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, OEP-XHE-XX-NR30MWR0, RCI-TDP-FR-TRAIN
2	C	3.53E-9	18.46	IE-LOOPWR, EPS-XHE-XL-NR30M, NSW-CKV-CF-EDGS, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FR-TRAIN
3	C	1.28E-9	6.72	IE-LOOPWR, EPS-DGN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, OEP-XHE-XX-NR30MWR0, RCI-TDP-TM-TRAIN
4	C	1.17E-9	6.14	IE-LOOPWR, EPS-FAN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FR-TRAIN
5	C	9.74E-10	5.10	IE-LOOPWR, EPS-XHE-XL-NR30M, NSW-CKV-CF-EDGS, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-TM-TRAIN
6	C	7.61E-10	3.98	IE-LOOPWR, EPS-DGN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, OEP-XHE-XX-NR30MWR0, RCI-TDP-FS-TRAIN
7	C	6.48E-10	3.39	IE-LOOPWR, ACP-CRB-CC-E1, ACP-CRB-CC-E2, EPS-XHE-XL-NR30M, OEP-XHE-XL-NR30MWR, RCI-TDP-FR-TRAIN
8	C	5.77E-10	3.02	IE-LOOPWR, EPS-XHE-XL-NR30M, NSW-CKV-CF-EDGS, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FS-TRAIN
9	C	5.00E-10	2.62	IE-LOOPWR, EPS-SEQ-CF-DGS, EPS-XHE-XL-NR30M, EPS-XHE-XL-SEQ, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FR-TRAIN
10	C	3.72E-10	1.95	IE-LOOPWR, EPS-DGN-CF-START4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FR-TRAIN
11	C	3.52E-10	1.84	IE-LOOPWR, EPS-DGN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, OEP-XHE-XX-NR30MWR0, RCI-RESTART, RCI-TDP-FS-RSTRT, RCI-XHE-XL-RSTRT
12	C	3.24E-10	1.69	IE-LOOPWR, EPS-FAN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-TM-TRAIN
13	C	2.67E-10	1.40	IE-LOOPWR, EPS-XHE-XL-NR30M, NSW-CKV-CF-EDGS, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-RESTART, RCI-TDP-FS-RSTRT, RCI-XHE-XL-RSTRT
14	C	2.39E-10	1.25	IE-LOOPWR, EPS-FAN-CF-START4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FR-TRAIN
15	C	1.92E-10	1.00	IE-LOOPWR, EPS-FAN-CF-RUN4, EPS-XHE-XL-NR30M, OEP-VCF-LP-SITEWR, OEP-XHE-XL-NR30MWR, RCI-TDP-FS-TRAIN

#### Cut Set Report - LODC1B 41

Only items contributing at least 1% to the total are displayed.

#	CASES	PROB/FREQ	TOTAL%	CUT SET
		3.47E-8	100	Displaying 28 Cut Sets. (28 Original)
1	C	1.84E-8	53.13	IE-TDC1B, ADS-XHE-XE-ADSBT, DCP-XHE-XA-ALTDC1
2	C	5.18E-9	14.95	IE-TDC1B, DCP-BAT-LP-1A1
3	C	2.87E-9	8.29	IE-TDC1B, DCP-BCH-LP-1A1, DCP-XHE-XM-LOADSHED, FLAG-BATTERY-BANK1A
4	C	2.08E-9	5.99	IE-TDC1B, DCP-BDC-LP-1A1
5	C	2.08E-9	5.99	IE-TDC1B, DCP-BDC-LP-DP3A
6	C	1.87E-9	5.39	IE-TDC1B, DCP-CRB-CO-DP3A
7	C	6.35E-10	1.83	IE-TDC1B, ACP-CRB-CC-E1, DCP-XHE-XA-ALTDC1, DCP-XHE-XM-LOADSHED, EPS-XHE-XM-SAMG, FLAG-BATTERY-BANK1A

#### Cut Set Report - LODC1B2 41

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Only items contributing at least 1% to the total are displayed.

<b>#</b>	<b>CASES</b>	<b>PROB/FREQ</b>	<b>TOTAL%</b>	<b>CUT SET</b>
		3.38E-8	100	Displaying 19 Cut Sets. (19 Original)
1	C	1.84E-8	54.47	IE-TDC1B2,ADS-XHE-XE-ADSBT,DCP-XHE-XA-ALTDC1
2	C	5.18E-9	15.32	IE-TDC1B2,DCP-BAT-LP-1A1
3	C	2.87E-9	8.50	IE-TDC1B2,DCP-BCH-LP-1A1,DCP-XHE-XM-LOADSHED,FLAG-BATTERY-BANK1A
4	C	2.08E-9	6.14	IE-TDC1B2,DCP-BDC-LP-1A1
5	C	2.08E-9	6.14	IE-TDC1B2,DCP-BDC-LP-DP3A
6	C	1.87E-9	5.52	IE-TDC1B2,DCP-CRB-CO-DP3A

## Referenced Events

Event	Description	Probability
ACP-BAC-LP-E1	DIVISION E1 AC POWER BUSES FAIL	3.33E-5
ACP-CRB-CC-E1	FAILURE OF BUS E1 NORMAL FEED BREAKER TO OPEN	2.39E-3
ACP-CRB-CC-E2	FAILURE OF BUS E2 NORMAL FEED BREAKER TO OPEN	2.39E-3
ACP-CRB-OO-AG0	FAILURE OF BUS E1 ALTERNATE FEED BREAKER TO CLOSE	2.39E-3
ACP-CRB-OO-AJ5	FAILURE OF BUS E3 ALTERNATE FEED BREAKER TO CLOSE	2.39E-3
ADS-XHE-XE-ADSBT	OPERATOR FAILS TO VALVE IN ADS NITROGEN BOTTLE BANK	1.00E-3
CSW-MDP-FC-CSTBY	CSW PUMP C IS IN STANDBY	3.33E-1
DCP-BAT-LP-1A1	DIVISION I 125 VDC BATTERY 1A1 FAILS	1.41E-5
DCP-BCH-LP-1A1	FAILURE OF DIVISION 1 BATTERY CHARGER 1A1	6.50E-5
DCP-BDC-LP-1A1	DIVISION I 125/250 VDC BUS 1A1 IS UNAVAILABLE	5.64E-6
DCP-BDC-LP-DP3A	FAILURE OF DISTRIBUTION PANEL 3A	5.64E-6
DCP-CRB-CO-DP3A	DISTRIBUTION PANEL 3A SUPPLY BREAKER FAILS TO REMAIN CLOSED	5.07E-6
DCP-XHE-XA-ALTDC1	FAILURE TO ALIGN ALTERNATE DC SUPPLY	5.00E-2
DCP-XHE-XM-LOADSHED	OPERATOR FAILS TO COMPLETE DC LOAD SHED	1.20E-1
EPS-DGN-CF-RUN4	COMMON CAUSE FAILURE OF ALL 4 DIESEL GENERATORS TO RUN	5.93E-5
EPS-DGN-CF-START4	COMMON CAUSE FAILURE OF ALL 4 DIESEL GENERATORS TO START	4.75E-6
EPS-DGN-FR-DG1	DIESEL GENERATOR 1 FAILS TO RUN	2.85E-2
EPS-FAN-CF-RUN4	FAILURE OF ALL FOUR DG EXHAUST FANS TO RUN	1.50E-5
EPS-FAN-CF-START4	FAILURE OF ALL FOUR DG EXHAUST FANS TO START	3.05E-6
EPS-SEQ-CF-DGS	CCF OF DGS SEQUENCER FAILURESS	6.38E-6
EPS-XHE-XL-NR30M	OPERATOR FAILS TO RECOVER EMERGENCY DIESEL IN 30 MINUTES	9.18E-1
EPS-XHE-XL-SEQ	OPERATOR FAILS TO RECOVER DG LOAD SEQUENCERS	1.00E+0
EPS-XHE-XM-SAMG	OPERATOR FAILS TO START AND ALIGN SAMG DG FOR 125VDC CHARGING	1.20E-1
FLAG-BATTERY-BANK1A	BATTERY BANK 1A DEPLETION FOLLOWING LOSS OF POWER FROM BATTERY CHARGER	1.00E+0
IE-LOIA	LOSS OF INSTRUMENT AIR SYSTEM	7.49E-3
IE-LOOPGR	LOSS OF OFFSITE POWER INITIATOR (GRID-RELATED)	1.22E-2
IE-LOOPSC	LOSS OF OFFSITE POWER INITIATOR (SWITCHYARD-CENTERED)	1.04E-2
IE-LOOPWR	LOSS OF OFFSITE POWER INITIATOR (WEATHER-RELATED)	3.91E-3
IE-TDC1B	LOSS OF VITAL DC BUS 1B	3.69E-4
IE-TDC1B2	LOSS OF VITAL DC BUS	3.69E-4
LCS-ICC-FC-N031A	LEVEL TRANSMITTER B21-LT-N031A FAILS HIGH	1.70E-3
LCS-ICC-FC-N031C	LEVEL TRANSMITTER B21-LT-N031C FAILS HIGH	1.70E-3
LCS-ICC-HI-N031ABCD	LEVEL INSTRUMENTS N031-A,B,C,D FAIL HI (PSA)	8.93E-5
LCS-MDP-TM-C001A	LCS MDP C001A UNAVAILABLE DUE TO TEST AND MAINTENANCE	7.12E-3
NSW-AOV-CC-V129	RHR RM A COOLER ISOLN VLV FAILS TO OPEN	9.51E-4
NSW-CKV-CF-EDGS	CCF - ALL UNIT 1 & 2 DG SW SUPPLY CKVs FAIL TO OPEN (PSA Value)	4.50E-5
NSW-MDP-FC-BRUN	NSW PUMP B IS RUNNING, PUMP A IS IN STANDBY	5.00E-1
NSW-MDP-FS-1A	NSW MDP 1A FAILS TO START	1.36E-3
NSW-MDP-TM-1A	NSW MDP 1A UNAVAILABLE DUE TO TEST AND MAINTENANCE	2.65E-2
NSW-MOV-CC-1SWV19	NSW MDP 1A DISCHARGE ISOL MOV SWS V-19 FAILS TO OPEN	9.63E-4
OEP-VCF-LP-SITEGR	SITE LOOP (GRID-RELATED)	8.18E-1
OEP-VCF-LP-SITESC	SITE LOOP (SWITCHYARD-RELATED)	2.11E-1
OEP-VCF-LP-SITEWR	SITE LOOP (WEATHER-RELATED)	6.92E-1
OEP-XHE-XL-NR30MGR	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 30 MINUTES (GRID-RELATED)	8.63E-1
OEP-XHE-XL-NR30MWR	OPERATOR FAILS TO RECOVER OFFSITE POWER IN 30 MINUTES (WEATHER-RELATED)	7.95E-1
OEP-XHE-XX-NR30MGR0	CONVOLUTION FACTOR FOR CCF-OPR (30MIN-GR Avail)	1.00E+0
OEP-XHE-XX-NR30MWR0	CONVOLUTION FACTOR FOR CCF-OPR (30MIN-WR Avail)	1.00E+0

OPR-XHE-XM-ALTUNITXC	OPERATOR FAILS TO CROSS-TIE DIVISION BUSES (2 HRS)	4.00E-3
PCS-XHE-XL-LODC1B	POWER CONVERSION SYSTEM RECOVERY FAILS DURING LODC1B	1.00E+0
PCS-XHE-XL-LODC1B2	POWER CONVERSION SYSTEM RECOVERY FAILS DURING LODC1B2	1.00E+0
RCI-MOV-CC-F013	RCIC INJECTION VALVE F013 CAUSES FAILURE TO START	9.63E-4
RCI-MOV-FC-XFER	RCIC FAILS TO TRANSFER DURING RECIRCULATION	7.97E-3
RCI-RESTART	RESTART OF RCIC IS REQUIRED	1.50E-1
RCI-TDP-FR-TRAIN	RCIC PUMP FAILS TO RUN GIVEN THAT IT STARTED	3.97E-2
RCI-TDP-FS-RSTRT	RCIC FAILS TO RESTART GIVEN START AND SHORT-TERM RUN	8.00E-2
RCI-TDP-FS-TRAIN	RCIC PUMP FAILS TO START	6.49E-3
RCI-TDP-TM-TRAIN	RCIC PUMP TRAIN IS UNAVAILABLE BECAUSE OF MAINTENANCE	1.09E-2
RCI-XHE-XL-RSTRT	OPERATOR FAILS TO RECOVER RCIC FAILURE TO RESTART	2.50E-1
RCI-XHE-XL-XFER	OPERATOR FAILS TO RECOVER SUCTN XFER FAILURE	2.50E-1
RCI-XHE-XO-ERROR	OPERATOR FAILS TO START/CONTROL RCIC INJECTION	1.00E-3
RHR-MOV-CC-F007A	RHR LOOP A MINFLOW VALVE F007A FAILS TO OPEN	9.63E-4
RHR-MOV-OO-F048A	RHR HEAT EXCHANGER A BYPASS VALVE F048A FAILS TO CLOSE	9.63E-4
RHR-STR-PG-S1	RHR LOOP A SUPPRESSION POOL STRAINER S1 PLUGS	4.90E-5
RHR-SYS-TM-A	RHR LOOP A UNAVAILABLE DUE TO TEST AND MAINTENANCE (PSA)	2.35E-3
RHR-XHE-XM-ERROR	OPERATOR FAILS TO START/CONTROL RHR FUNCTIONS	5.00E-4
RHR-XHE-XM-NPSH	FAILURE TO CONTROL LPCI OPERATION UNDER LOW NPSH CONDITIONS (PSA)	1.00E-1
RSW-MOV-CC-F068A	RHR HX1A FLOW CONTROL MOV F068A FAILS TO OPEN	9.63E-4