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ENCLOSURE 2

PSA-ES054, Revision 0
"Risk Evaluation Non-Conforming EQ Leads on PS-300 Switches"
8 Pages

PROBABILISTIC SAFETY ASSESSMENT

COOPER NUCLEAR STATION

ENGINEERING STUDY

Risk Evaluation Non-Conforming EQ Leads on PS-300 Switches

PSA-ES054

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Problem Statement

The OE for PIR 4-11673 determined the impact of the PS-300 pressure switches not being in a qualified condition. This OE performed an FMEA for each failure mode identified. A white paper was written to deterministically evaluate any synergistic effects of these failure modes. This paper evaluates the synergistic effects in a probabilistic manner.

In this evaluation, the plant condition evaluated was the "as found" configuration of the plant discovered during the 2000 EQ forced outage.

The purpose of this evaluation is to determine if the results of the risk significance evaluation of the EQ issue remain valid.

Assumptions

1) Configuration of the plant was as described in PSA-ES051, with the addition of the condition described in the problem statement above.

2) The assumptions and data in PSA-ES051 apply.

3) PSA 96b model results apply.

4) Existing ground faults on the 125 VDC system that are too small to be detected by the ground fault detection circuitry (greater than 150 ohms) would not allow enough fault current to challenge the fuses in the SRV circuitry.

5) If a ground fault occurs on the leads to the inboard MSIV solenoids, the 5 amp fuse in this circuit will open prior to the 10 amp fuses in the SRV circuitry.

6) CNS has not operated with a hard ground (a ground that alarms in the control room) on either 125 VDC division for longer than 69 hours. If a ground is detected, it will be promptly investigated and corrected. If it cannot be corrected within a few hours, then the DC division will be declared inoperable and a 2 hour shutdown LCO action will be entered. The plant will be shutdown in less than 24 hours.

Limitations of this Evaluation

This evaluation considers only the plant configurations stated in the problem statement and assumptions. This evaluation is to be used only to characterize the risk significance of the plant configuration described in accordance with the Revised Reactor Oversight Process (RROP).

Conclusion

The addition of the PS-300 leads to the list of unqualified EQ components at CNS does not change the results of PSA-ES051 unless one of the following conditions existed:

1) A ground fault of sufficient magnitude to be identified by the ground detection circuitry existed on the negative side of both 125 VDC divisions for a duration of greater than 19 days.

2) A ground fault of sufficient magnitude to be identified by the ground detection circuitry existed on the negative side of both 125 VDC divisions with a concurrent unavailability of HPCI for a duration greater than 69 hours or RCIC for a duration greater than 87 hours.

3) Either 1) or 2) above except that the fault was only on Division II 125 VDC and the next inspection or test (subsequent to the fault) of the inboard MSIV solenoid fuses discovered one or more of the fuses failed in a short circuit mode.

Since there is no evidence that any of these conditions existed, the results of PSA-ES051 remain valid. The risk evaluation of the EQ non-conforming condition is green under the RROP.

Evaluation

The drywell cases from PSA-ES051 were re-evaluated with four different conditions.

Case 1

The first case assumed that all of the SRV's were failed. This corresponds to a plant condition in which both divisions of 125 VDC have a ground fault on their negative side or there is a ground fault on the negative side of Division II 125 VDC with a concurrent fuse failure (short circuit) on one of the inboard MSIV solenoids. In this scenario, a LOCA environment is assumed to cause the unqualified cables to short to ground on the positive side. This would cause the fuses in the SRV control circuit on the Division I side to open. The power transfer relay would then transfer the control circuit power to the Division II side, but since there is a short to ground existing on that side as well, the Division II fuses would also open.

The CDF for this scenario is 1.85×10^{-5} per year [Table 2], which is 1.84×10^{-5} per year above the base case for the drywell [Table 1]. Combining this with the rest of the HELB areas from PSA-ES051 results in a total increase of 1.86×10^{-5} per year. In order for this scenario to be green, it must have a Core Damage Probability (CDP) of less than 10^{-6}. Since CDP is the product of CDF and the duration of the condition, this configuration could only exist for 19.7 days before the condition would be considered white.

There is no evidence that ground faults existed on either division for this long of a duration.

Case 2

The second case assumed that all of the SRV's were failed and HPCI was unavailable. This corresponds to a plant condition in which both divisions of 125 VDC have a ground fault on their negative side or there is a ground fault on the negative side of Division II 125 VDC with a concurrent fuse failure (short circuit) on one of the inboard MSIV solenoids. In this scenario, a LOCA environment is assumed to cause the unqualified cables to short to ground on the positive side. This would cause the fuses in the SRV control circuit on the Division I side to open. The power transfer relay would then transfer the control circuit power to the Division II side, but since there is a short to ground existing on that side as well, the Division II fuses would also open. In addition, HPCI would be unavailable to inject in either the small or medium LOCA cases.

The CDF for this scenario is 1.26×10^{-4} per year [Table 3], which is 1.26×10^{-4} per year above the base case for the drywell. Combining this with the rest of the HELB areas and HPCI unavailable from PSA-ES051 results in a total increase of 1.26×10^{-4} per year. In order for this scenario to be green, it must have CDP of less than 10^{-6}. This configuration could only exist for 69.5 hours before the condition would be considered white.

There is no evidence that ground faults existed on either division for this long of a duration. If the fault did not exist, then any HPCI unavailability would be covered by the evaluation in PSA-ES051.

It should be noted that this case is dominated by medium LOCAs. If this configuration existed, the medium LOCA initiator would lead directly to core damage.

Case 3

The third case is the same as the second, except that RCIC was assumed unavailable rather than HPCI.

The CDF for this scenario is 9.97×10^{-5} per year [Table 4], which is 9.96×10^{-5} per year above the base case for the drywell. Combining this with the rest of the HELB areas and HPCI unavailable[1] from PSA-ES051 results in a total increase of 9.98×10^{-5} per year. In order for this scenario to be green, it must have CDP of less than 10^{-6}. This configuration could only exist for 87.8 hours before the condition would be considered white.

There is no evidence that ground faults existed on either division for this long of a duration. If the fault did not exist, then any RCIC unavailability would be covered by the evaluation in PSA-ES051.

In this condition, there are no sequences where the initiator leads directly to core damage.

Case 4

The fourth case assumed that the SRV's had an increased failure probability to account for the common cause failure of the control power transfer relays. This corresponds to the condition in which only the Division I 125 VDC system has a ground fault on its negative side. In this scenario, a LOCA environment is assumed to cause the unqualified cables to short to ground on the positive side. This would cause the fuses in the SRV control circuit on the Division I side to open. The SRV's would not be able to perform their function if the power transfer relays fail to change state.

The base failure rate for a single relay in the CNS PRA is 3×10^{-4} per demand. More than five power transfer relays would need to fail in order to affect the ability of the SRV's to depressurize the reactor. The random failure of more than five would be negligible, but a common cause failure could produce a more credible scenario. If a beta factor of 0.056 is used for the common cause failure of six or more relays, the increase in the SRV common cause failure rate would be 1.7×10^{-5} per demand. This is a conservative value, since an average beta factor for four electrical components is 0.056 and in this case more than five need to fail.

Based on a search of available literature, a beta factor for relay failure could not be found. This is because the value is typically too small to be included in PRAs. For the purpose of this evaluation, the value cited above was estimated by averaging the available beta factors for components that contain relays that are modeled by common cause failure in the CNS PRA [Table 6]. SRV failures were not included in this average because they are already explicitly included in the failure event for the SRVs in the model.

The common cause SRV failure basic event was increased from 2.4×10^{-4} per demand to 2.57×10^{-4} per demand by adding in the common cause relay failure rate (1.7×10^{-5} per demand). This resulted in a CDF of 1.59×10^{-7} per year [Table 5], which is 1.97×10^{-8} per year above the base case for the drywell. This is only 4×10^{-10} per year greater than the CDF increase estimated in PSA-ES051. This small of an increase is considered negligible.

If the fault were only on Division I, the change in the results from PSA-ES051 is negligible.

Other Considerations

Since the CDF increase from case 4 was so small, this condition was not re-evaluated with HPCI or RCIC unavailable. It can be inferred that the increases from these conditions will be much smaller than from cases 2 and 3.

The unavailability of a 125 VDC division was not considered in this evaluation. CNS has not been in a power operation mode with a DC division unavailable. There are times that a charger may be out of service, but that does not affect the reliability of the system (as it is modeled in the PRA) since the battery is the main source of power. Also, when CNS was experiencing degradation of its battery cells, the DC division remained available throughout the condition.

[1] PSA-ES051 did not have a RCIC unavailable case for the other HELB areas. For breaks outside the drywell, HPCI and RCIC unavailabilities have similar effects on the results, so using the "HPCI unavailable" case for the estimate of the line breaks outside the drywell is appropriate.

Other failures could cause the same result as the common cause failure of the transfer relays, however, this would always require multiple failures. The common cause failure of the transfer relays is the most probable of the scenarios that would lead to the same effect.

References

1) CNS PSA 96b

2) PSA-ES051 revision 2

3) OE for PIR 4-11673

4) White Paper on Cumulative Effects for Conditions described in OE for PIR 4-11673

5) PAG-005, Project Analysis Guideline for the CNS Probabilistic Risk Assessment Data Analysis Task

Table 1 – Results from PSA-ES051

	Base	EQ	Delta EQ	EQ & HPCI	Delta EQ&HPCI
Drywell	1.39E-07	1.59E-07	1.93E-08	2.07E-07	6.75E-08
Steam Tunnel	1.16E-07	2.57E-07	1.41E-07	2.57E-07	1.41E-07
HPCI Room	2.22E-10	3.24E-10	1.02E-10	3.24E-10	1.02E-10
NE Quad	2.35E-11	2.35E-11	5.91E-14	1.16E-10	9.24E-11
SW Quad	8.45E-12	1.89E-11	1.05E-11	1.89E-11	1.05E-11
East Torus	5.27E-12	3.45E-11	2.92E-11	3.45E-11	2.92E-11
West Torus	7.97E-11	2.83E-09	2.75E-09	2.83E-09	2.75E-09
RHR HX A	2.52E-11	3.54E-11	1.02E-11	3.54E-11	1.02E-11
RHR HX B	8.29E-12	1.21E-11	3.78E-12	1.21E-11	3.78E-12
Inject Valve Room	6.06E-11	1.18E-10	5.74E-11	1.18E-10	5.74E-11
RWCU P A	1.48E-11	1.48E-11	0.00E+00	5.93E-11	4.46E-11
RWCU P B	1.48E-11	1.48E-11	0.00E+00	5.93E-11	4.46E-11
RWCU HX	4.19E-11	4.19E-11	0.00E+00	1.40E-10	9.79E-11
Total	2.56E-07	4.20E-07		4.68E-07	
Increase			1.63E-07		2.12E-07

Table 2 – Case 1 Results

Case:	Drywell Case 1 (EQ issues and SRVs)				
Data File:	DATADW5.96A				
Initiator	Sequence	Search String	Initiator Frequency	CCDP	CDF
LLOCA	LL	=LL-*	1.99E-04	4.95E-04	9.85E-08
	AWA	=AWA-*	1.99E-04	1.00E-05	1.99E-09
MLOCA	S1	=S1-*	7.79E-05	1.26E-01	9.83E-06
	AWS1	=AWS1-*	7.79E-05	1.00E-05	7.79E-10
SLOCA	S2	=S2-*	7.25E-04	1.17E-02	8.51E-06
	AS2	=AS2-*	7.25E-04	1.40E-05	1.01E-08
LEAK	S3	=S3-*	9.43E-05	6.99E-09	6.59E-13
	S3T3	=S3T3-*	9.43E-05	4.39E-04	4.14E-08
	S3S2	=S3S2-*	9.43E-05	2.62E-10	2.47E-14
Total:					1.85E-05

Table 3 – Case 2 Results

Case:	Drywell Case 2 (EQ issues & HPCI, and SRVs failed)				
Data File:	DATADW4.96A				
Initiator	Sequence	Search String	Initiator Frequency	CCDP	CDF
LLOCA	LL	=LL-*	1.99E-04	4.95E-04	9.85E-08
	AWA	=AWA-*	1.99E-04	1.00E-05	1.99E-09
MLOCA	S1	=S1-*	7.79E-05	1.00E+00	7.79E-05
	AWS1	=AWS1-*	7.79E-05	1.00E-05	7.79E-10
SLOCA	S2	=S2-*	7.25E-04	6.57E-02	4.76E-05
	AS2	=AS2-*	7.25E-04	1.32E-05	9.60E-09
LEAK	S3	=S3-*	9.43E-05	6.99E-09	6.59E-13
	S3T3	=S3T3-*	9.43E-05	5.06E-03	4.77E-07
	S3S2	=S3S2-*	9.43E-05	2.62E-10	2.47E-14
Total:					1.26E-04

Table 4 – Case 3 Results

Case:	Drywell Case 3 (EQ issues & RCIC and SRVs failed)				
Data File:	DATADW7.96A				
Initiator	Sequence	Search String	Initiator Frequency	CCDP	CDF
LLOCA	LL	=LL-*	1.99E-04	4.95E-04	9.85E-08
	AWA	=AWA-*	1.99E-04	1.00E-05	1.99E-09
MLOCA	S1	=S1-*	7.79E-05	1.26E-01	9.83E-06
	AWS1	=AWS1-*	7.79E-05	1.00E-05	7.79E-10
SLOCA	S2	=S2-*	7.25E-04	1.23E-01	8.91E-05
	AS2	=AS2-*	7.25E-04	1.37E-05	9.92E-09
LEAK	S3	=S3-*	9.43E-05	6.99E-09	6.59E-13
	S3T3	=S3T3-*	9.43E-05	7.07E-03	6.67E-07
	S3S2	=S3S2-*	9.43E-05	2.62E-10	2.47E-14
Total:					9.97E-05

Table 5 – Case 4 Results

Case:	Drywell Case 4 (EQ issues and SRV's need relays to transfer DC power)				
Data File:	DATADW6.96A				
Initiator	Sequence	Search String	Initiator Frequency	CCDP	CDF
LLOCA	LL	=LL-*	1.99E-04	4.95E-04	9.85E-08
	AWA	=AWA-*	1.99E-04	1.00E-05	1.99E-09
MLOCA	S1	=S1-*	7.79E-05	8.90E-05	6.93E-09
	AWS1	=AWS1-*	7.79E-05	1.00E-05	7.79E-10
SLOCA	S2	=S2-*	7.25E-04	5.50E-05	3.99E-08
	AS2	=AS2-*	7.25E-04	1.40E-05	1.01E-08
LEAK	S3	=S3-*	9.43E-05	6.99E-09	6.59E-13
	S3T3	=S3T3-*	9.43E-05	9.44E-06	8.90E-10
	S3S2	=S3S2-*	9.43E-05	2.62E-10	2.47E-14
Total:					1.59E-07

Table 6 – Common Cause Beta Factors

	Beta Factor		
Number of Concurrent Failures	2	3	4
Equipment Type			
Diesel Generators	0.038	0.018	0.013
Service Water Pumps	0.026	0.014	0.0096
Low Pressure ECCS Pumps	0.15	0.11	0.1
High Pressure ECCS Pumps	0.21	0.1	
Motor Operated Valves	0.088	0.054	0.057
Air Operated Valves	0.1	0.1	0.1
Average	0.102	0.066	0.05592