Evaluation of Loss of Offsite Power events at Nuclear Power Plants in Korea

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1. Introduction

It is recognized that the availability of AC power to nuclear power plants is essential for safe operation and to maintain safe shutdown. In the PSAs has been performed in Korea, the Risk is induced from LOOP(loss of off-site power) and SBO(station blackout) are considered important contributors to total risk at nuclear power plant. In the KSNP PSAs, the Risk induced from those two events are over 30% of total CDF(core damage frequency). Therefore, a LOOP and its restoration time are important inputs to plant risk model, and these inputs must reflect specific operation experience. In this study, the LOOP Events has occurred at commercial nuclear power plants in Korea were collected during 1978 through 2004. Total 14 LOOP Events has been collected and analyzed. This paper contains a description of the LOOP data collection, analysis results to utilize PSA & Risk informed application, engineering insight and the major conclusions of this study.

2. Data

For this study, the operating experience data from plant trip data base program has been reviewed involving some electrical failure that occurred at commercial nuclear power plants in Korea from 1978 through 2004. To produce results for use in PSA or Risk informed application, the frequency was estimated and the time to recovery was defined as time until offsite power could have been restored to at least one safety bus from an alternate electrical power source. The plants status in which the LOOP events occurred and main cause are also defined for engineering insight. A total 14 LOOP events are specified for this study (Loss of Off-site Power) and summarized in Table 1.

Table 1. LOOP Events at nuclear power plants in Korea

	Unit	Unit Status	Description	Cause	Duration
1	Kori 4	at power	SUT 'A' & 'B' & MOT Trip caused by salt spray	Typhoon	7hrs 45min
2	Kori 3	O/H			7hrs 45 min
3	Kori 1	at power	T/L Failure	Severe wind	less than 2 min.
4	Kori 2	at power			
5	Kori 1	at power	Kori #1 & #2 345kV T/L failure & 145kV #1 failure caused by salt spray	Typhoon	8hrs
6	Kori 2	at power	Kori #1 & #2 345kV T/L failure & 154kV #1T/L failure caused by salt spray		8hrs
7	Kori 3	at power	SUT flashover caused by salt spray		9hrs 36min
8	Kori 4	at power	SUT flashover caused by salt spray		9hrs 36min
9	UCN 1	at power	345kV #1 & #2 in T/L Line	Heavy snow	28min
10	UCN 2	at power	345kV #1 & #2 in T/L line		28min
11	WOL 1	at power	GIS failure in switchyard	Component failure	less than 2 min.
12	UCN 1	at power	Local forest fires T/L Line	forest fires	less than 2 min.
13	UCN 2	at power	local forest fires T/L Line		less than 2 min.
14	Wol 2	Shutdown	C/B Fault in switchyard	Human error	3hrs 53 min

* house load operation

3. Analysis

The main objectives of this paper is to identify LOOP events to utilize the LOOP frequencies and its subsequent restoration time for the Korean NPPs specific risk model. The additional objective of this study is to obtain the engineering insights from LOOP events such as root causes and multi units effects events. For this study, the LOOP event was considered an initiating event defined as a simultaneous loss of electrical power to all unit safety buses, requiring the emergency power generators to start and supply power to safety buses if the plant is at power operation or shutdown operation. At most units, a LOOP cause the reactor trip, but some unit designs allow continued operation at power following a complete the LOOP event, with the safety buses supplied by house load operation. Two cases of Loop events(#9 & #10 events in table 1) were continuing power operation with the safety buses supplied by house load operation after LOOP event because of their specific design. These two cases could be excluded from LOOP events. But in most of PSA performed in Korea, the house load operation has not been credited because that operation has succeeded rarely in operating experience. In this study, a LOOP is defined as simultaneous loss of electrical power from off site power in switchyard if the reactor did not trip following the LOOP event.

The LOOP events have been generally classified into three category such as plant-centered, grid related and severe weather-related events. In this study, 2 events were classified a plant-centered LOOP, 4 events were classified grid-related LOOP and 8 events were classified severe weather-related LOOP. All of 8 events defined LOOP events are include the weather related events such as a typhoon and heavy snow.

A second distinction made is between *momentary* and *sustained* events. The event, that offsite power was recovered in 2 minutes, was classified momentary event. The 4 of 14 LOOP events are classified momentary LOOP and the others are classified sustained LOOP event.

In addition, LOOP events could be grouped according to plant status such as plant operating or shutdown. 2 of 14 events occurred during plant shutdown.

The external causes(two typhoon and one heavy snow) could have the potential to affect all units at a same site. In table 1, 12 LOOP events considered in this study were involving external causes related the Multi-Units LOOP.

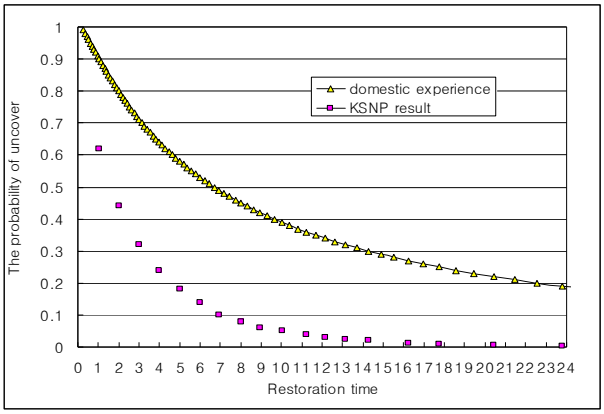
The preliminary quantitative analysis for LOOP initiating events frequency and its restoration time are performed. The quantitative results of each LOOP category were summarized in Table 2. The results were also compared with the recent data in the U.S. The restoration time analysis for only sustained LOOP events also is performed. The result for restoration time is summarized in figure 1. The restoration time is much longer than that of risk assessment applied the KSNP PSA performed in Korea.

Table 2. The Results of LOOP frequency analysis

	Operating year	# of events	Frequency
Domestic Experience (1978-2004)	197Ry	12	0.06/ry(at power)
	32.6Sy	2	0.06/sry(shutdown)
The U.S. Experience (1997-2004)	724Ry	24	0.04/ry(at power)
	383Sy	73	0.19/sry(shutdown)

* Ry : Reactor Year, Sy:Shutdown Year

Figure 1. The Results of LOOP frequency analysis



3. Conclusion

It is recognized that the availability of AC power to nuclear power plants is essential for safe operation and shutdown. To utilize PSA & Risk informed application, and get a engineering insight, a total of 14 LOOP events are collected and analyzed. The preliminary quantitative results between Korean specific data and U.S. data did not show a big difference at power operation while there is a big difference between them during shutdown status. The restoration time is much longer than that of risk assessment applied the KSNP PSA performed in Korea.

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