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Transient Event Experiences for Nuclear Power Plants in Korea

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I. INTRODUCTION

It is recognized that operating experience data is essential for an accident analysis (including Probabilistic Safety Assessment) and other quantitative activities such as a Risk or Performance informed application for a nuclear power plant. The data for a PSA or other quantitative activities have to use specific data with respected to the domestic operation characteristic, because they are considered important contributors to the total risk at a nuclear power plant.

The main purpose of this study is to develop transient initiating event frequencies from Korean domestic operational data to utilize them in a PSA or Risk(or performance) informed application. For the objectives, Korean specific nuclear power plants transient data were gathered and EPRI PWR transient category analysis was performed to provide the information they contain in ways useful for a probabilistic safety assessment and other quantitative activities.

II. Data gathering and Database program development

For this study, unplanned plant transient data has been gathered from all the commercial nuclear power plants in Korea during April 1978 in which the first nuclear power plant(Kori 1 Unit) started its commercial operation through the end of 2004. During this duration, about 515 plant transient events were gathered from 19 commercial operating nuclear power plants and the cumulative operating experience has been about 164 reactor operating years. After the data were collected each transient was reviewed and categorized to apply it to a PSA or other quantitative activities. In table 1, the accumulated operating years and the number of unplanned transient events collected from each plant are summarized.

In order to analyze the data, the computer-based database program was developed to display information from the data collected. After the data was collected and inserted into to the database program, each transient was reviewed and analyzed.

III. Analysis.

Transient initiating event frequencies are an essential input to the analysis process of a nuclear power plant PSA or quantitative activities. To evaluate the initiating event frequencies, all the events except for the events which occurred in CANDU Type plants(4 plants are CANDU type in Korea) are inserted into the computer program according to the EPRI PWR transient category.

Table 1. Summary on the operating year & number of events for each units

Unit	Cal. Year	Rx. Year	# of events
1	26.69	21.07	118
2	21.45	18.32	57
3	19.26	16.38	40
4	18.68	15.95	37
5	18.36	15.95	35
6	17.57	15.00	35
7	9.76	8.65	14
8	9	7.96	13
9	2.61	2.04	7
10	2	1.62	1
11	16.32	13.85	33
12	15.26	13.24	25
13	6.39	5.82	4
14	5	4.49	10
15	0.42	0.43	1
16*	21.71	18.64	57
17*	7.5	6.71	16
18*	6.5	5.90	9
19*	5.25	4.93	3
total	229.74	197.19	515

* CANDU type plant

The EPRI PWR category #35 subdivided into five subsets could be applied to a PSA directly and a steam generator tube rupture event is added in the EPRI PWR category # 26. In table 2, the result of the EPRI Category classification ewrw summarized

In this study, the 9 transient itiating events frequencies and 1 steam generator tube rupture events that have been experienced in Korea were evelauated to reflect the domestic operating experience. The results were also compared with the U.S recent initiating transient frequencies and the results of this evaluation are summarized in Table 3.

Table 2. The results of the EPRI PWR Transient category classification

EPRI Category		# of event
EPRI 1	Loss of RCS Flow (1 Loop)	6
EPRI 2	Uncontrolled Rod Withdrawal	0
EPRI 3	CRDM Problems and/or Rod Drop	43
EPRI 4	Leakage from Control Rods	1
EPRI 5	Leakage in Primary System	14
EPRI 6	Low Pressurizer Pressure	1
EPRI 7	Pressurizer Leakage	1
EPRI 8	High Pressurizer Pressure	0
EPRI 9	Inadvertent Safety Injection Signal	2
EPRI 10	Containment Pressure Problems	0
EPRI 11	CVCS Malfunction – Boron Dilution	0
EPRI 12	Pressure/Temperature/Power Imbalance - Rod Position Error	1
EPRI 13	Startup of Inactive Coolant Pump	0
EPRI 14	Total Loss of RCS Flow	4
EPRI 15	Loss or Reduction in Feedwater Flow (1 loop)	43
EPRI 16	Total Loss of Feedwater Flow (all loops)	12
EPRI 17	Full or Partial Closure of MSIV (1 loop)	12
EPRI 18	Closure of All MSIV	6
EPRI 19	Increase in Feedwater Flow (1 Loop)	11
EPRI 20	Increase in Feedwater Flow (All Loop)	0
EPRI 21	Feedwater Flow Instability-Operator Error	5
EPRI 22	Feedwater Flow Instability-Miscellaneous Mechanical Causes	4
EPRI 23	Loss of Condensate Pumps (1 Loop)	0
EPRI 24	Loss of Condensate Pumps (All Loops)	0
EPRI 25	Loss of Condenser Vacuum	6
EPRI 26	Steam Generator Leakage - Steam Generator Tube Rupture : 1	5
EPRI 27	Condenser Leakage	2
EPRI 28	Miscellaneous Leakage in Secondary System	7
EPRI 29	Sudden Opening of Steam Relief Valves	0
EPRI 30	Loss of Circulating Water	15
EPRI 31	Loss of Component Cooling	2
EPRI 32	Loss of Service Water System	0
EPRI 33	Turbine Trip, Throttle Valve Closure, EHC Problems	52
EPRI 34	Generator Trip or Generator Caused Faults	61
EPRI 35	Loss of All Offsite Power	8
EPRI 36	Pressurizer Spray Failure	0
EPRI 37	Loss of Power to Necessary Plant Systems -Loss of 13.8KV power: 24 -Loss of 4.16kV power: 10 -Loss of 125V DC power: 1 -Loss of 120V AC power: 11 -Loss of 480V AC power: 3	49
EPRI 38	Spurious Trips-Cause Unknown	0
EPRI 39	Automatic Trip-No Transient Condition	20
EPRI 40	Manual Trip-No Transient Condition	14
EPRI 41	Fire Within Plant	2

Most of the initiating event cases, for an arithmetic average of the Korean specific data is higher than that of the U.S experience because the Korean operating experience is too short when compare to the U.S operating experience during the Bayesian updating process.

IV. CONCLUSIONS

In this study, unplanned plant transient are gathered and analyzed. An initiating event frequencies evaluation were performed to obtain an insight from the Korean domestic data.

Table3. The result of the preliminary initiating events frequency analysis

No.	Initiating Event	KSNP		NUREG/CR - 5750	
		Arithmetic Average	Mean*	Arithmetic Average	Mean*
1	Steam Generator Tube Rupture	0.007	7.10E-3	0.006	7.0E-3
2	Loss of Main Feedwater	0.155	0.084	0.064	0.065
3	Loss of Condenser Vacuum	0.170	0.049	0.054	0.028
4	Loss of a CCW Train	0.0148	5.13E-1	0.001	9.7E-4
5	Loss of a 4.16KV AC bus	0.074	0.024	0.014	0.014
6	Loss of a 125V DC Bus	0.007	1.7E-3	N/A	6.9E-4
7	Loss of Offsite Power	0.059	3.0E-2	0.023	2.4E-2
8	Station Blackout		3.66E-5		N/A
9	General Transients	1.04	0.946	0.972	1.2
10	Loss of a 120V AC Bus	0.074	1.3E-2	0.001	2.1E-3

Mean* : After Bayesian Update

The preliminary Bayesian update with the Korean specific data and the U.S data did not not show a big difference, because the Korean operating experience is too short when compare to the U.S operating experience. The Korean specific transient database would of cause be updated yearly and the results of this study could be used as basic information for a probabilistic risk assessment and other quantitative activities in Korea.

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