Evaluation of Neutron Detectors for Improving the Failed Fuel Location System

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1. Introduction

The failed fuels produced during the reactor operation should be replaced rapidly with the fresh ones to minimize the radioactive contamination of reactor and heat transport system. The failed fuel monitoring system in heavy water reactor is finding out the defective fuels by detecting the neutron and gamma radiation emitting from the fission products in coolant. The monitoring system consists of two sub-system, one is gaseous fission product detection system for the defective fuels in the whole fuel channels, and the other is the delayed neutron detection system for the failed fuel location in particular channel. In this work, two neutron detectors were compared and evaluated for which detector is more sensitive to the neutron by detecting the delayed neutron at the coolant sampling lines in the nuclear power plant. The purpose of this work is to collect some reference data for replacing the existing detector with a more sensitive one.

2. Experiments

2-1. Method

An evaluation test of detector sensitivity was performed in the delayed neutron measuring room equipped with the coolant sampling lines of the failed fuel location system. Usually, delayed neutron measurement is carried out in the period of 2 weeks and when defective fuel is sensed by gaseous fission product measurement in Wolsong site. This experiment was performed in a situation of no defective fuel signals in the gaseous fission product monitoring system. It was only an experiment for evaluating the detector sensitivity in the condition of on-site measurement. Onsite experiment is advantageous terms compared to the cold area experiment using checking source because there can be gaseous fission products and activation products of coolant including anti-corrosion chemicals in the heat transport system of the reactor. In this work, 108 lines of 380 sampling lines corresponding to the whole fuel channels were measured with the He-3 neutron detector.

2-2. Apparatus

A He-3 detector(model: Reuter Stokes RS P4-0810-117) was selected and employed in this experiment after performing the sensitivity test of 5 detectors in cold laboratory. It was experimentally confirmed that this detector was sensitive to the neutron emitting from Cf-252 checking source. In cold and on-site test, AMSR(Advanced Multiplicity Shift Resister) and PDT 110-A preamplifier/amplifier were used as an electronic equipment.

2-3. Measuring conditions

The applied voltage of RS P4-0810-117 detector, 1,600V, was determined by the optimum operating voltage test carried out by detecting the neutrons emitting from the coolant sampling lines of the failed fuel monitoring system in the nuclear power plant. The measuring time of 30 seconds was also experimentally determined in consideration of minimizing the statistical error. And the measurements were done 2 times a sampling line in order to increase the reliability.

3. Results

108 lines of 380 sampling lines corresponding to the whole fuel channels were measured, and the data acquired from each channel were listed with the one of KHNP(Korea Hydro & Nuclear Power Co., LTD)in Table 1. The

rest lines will be measured in the future after preparing the protectors and auxiliary tools against the personnel exposure. As a result of the data analysis, it was confirmed that RS P4-0810-117 detector is more sensitive than the existing BF_3 detector(LND-203) used in the delayed neutron monitoring system of Wolsong nuclear power plant as shown in Fig.1.

4. Conclusions

It was confirmed that RS P4-0810-117 detector is more sensitive than the existing BF_3 detector(LND-203) used in the delayed neutron monitoring system by analyzing the data acquired from the on-site experiments at Wolsong Unit-4. And it will be used for the reference data to replace the existing detector with a more sensitive one, if any plan.

Table 1. Results of DN Measurement in DN Sampline Line of Wolsung Unit 4

	Channel Position	Measurement, cps			Measurement(KHNP)		Channel Power(kW)	Remark
		1st	2nd	Avg	2004-11-11	Avg		
1	Q13	18.750	18.353	18.552	11.760	9.534	6293	R-303
2	S11	15.917	18.067	16.992	11.120	9.410	6340	R-303
3	K17	18.783	20.300	19.542	9.220	8.278	6339	R-303
4	M09	15.050	14.800	14.925	8.280	7.143	5957	R-303
5	K03	16.667	16.700	16.684	9.960	8.806	5860	R-303
6	J22	11.850	10.183	11.017	6.680	5.423	3257	R-303
7	U13	15.333	14.617	14.975	7.840	6.582	5046	R-303
8	O11	17.333	16.250	16.792	10.600	8.134	6405	R-303
9	K07	26.083	23.867	24.975	13.180	11.121	6594	R-303
10	J14	15.167	16.300	15.734	7.280	6.979	6630	R-303
11	J10	17.483	18.117	17.800	10.900	8.069	6514	R-303
12	N12	17.100	16.550	16.825	8.140	7.591	5994	R-303
13	W11	15.117	15.333	15.225	9.900	8.886	2804	R-303
14	T12	13.250	13.833	13.542	9.620	7.240	6054	R-303
15	J08	31.250	29.617	30.434	16.140	13.342	6476	R-303
16	R12	13.800	13.583	13.692	6.520	5.477	6514	R-303
17	P10	25.017	24.783	24.900	13.840	11.939	6306	R-303
18	N14	15.183	14.883	15.033	7.840	7.236	6491	R-303
19	D11	18.317	18.750	18.534	13.360	10.077	6123	R-303
20	W13	15.217	16.000	15.609	9.300	7.681	2971	R-303
21	J12	12.317	13.283	12.800	8.000	6.594	5868	R-303
22	U11	15.867	16.950	16.409	9.980	9.580	5239	R-303
23	R10	21.183	21.150	21.167	10.260	9.687	6699	R-303
24	K15	18.667	19.500	19.084	9.840	9.093	6518	R-303
25	J18	13.067	11.883	12.475	9.180	7.271	6385	R-303
26	O09	25.433	24.900	25.167	16.060	12.926	6630	R-303
27	L10	17.900	17.833	17.867	10.620	8.510	6230	R-303
28	L14	17.200	17.383	17.292	10.200	8.613	6608	R-303
29	O13	19.267	19.067	19.167	10.680	8.573	6269	R-303
30	K05	24.767	24.533	24.650	14.520	11.360	6203	R-303
31	T10	20.667	19.883	20.275	12.500	11.261	6290	R-303
32	J20	14.583	14.183	14.383	8.660	7.827	5440	R-303
33	J16	22.133	22.067	22.100	12.200	11.273	6541	R-303
34	K01	13.550	13.500	13.525	7.380	6.882	3719	R-303
35	N10	20.550	20.950	20.750	10.700	9.066	6439	R-303
36	K13	17.100	16.083	16.592	7.880	7.175	6421	R-303
37	M13	14.583	15.200	14.892	10.600	7.783	6171	R-303
38	Q11	17.667	17.933	17.800	12.780	10.556	6253	R-303
39	G06	34.167	34.433	34.300	24.400	21.056	5969	R-303
40	P12	17.133	17.100	17.117	9.420	7.665	6748	R-303
41	S13	16.867	18.633	17.750	9.380	7.736	6729	R-303
42	K09	19.000	17.733	18.367	10.320	8.967	6114	R-303
43	K21	16.517	16.600	16.559	9.300	8.339	4586	R-303
44	S09	18.767	19.750	19.259	12.760	11.244	6235	R-303
45	H03	18.083	20.183	19.133	11.860	10.678	4809	R-303
46	T14	13.483	13.800	13.642	7.840	5.814	6076	R-303
47	G14	21.167	21.067	21.117	9.420	9.512	6019	R-303
48	M07	18.167	18.733	18.450	8.400	7.550	6701	R-303
49	N16	18.150	18.917	18.534	11.480	9.400	6350	R-303
50	P08	21.450	20.367	20.909	12.760	11.295	6846	R-303

	Channel Position	Measurement, cps			Measurement(KHNP)		Channel Power(kW)	Remark
		1st	2nd	Avg	1901-02-09	Avg		
51	H07	25.717	26.550	26.134	17.220	14.419	6748	R-303
52	Q15	18.000	18.767	18.384	11.680	10.364	6832	R-303
53	H17	17.383	16.000	16.692	7.780	8.472	6359	R-303
54	G10	24.833	24.033	24.433	16.280	13.775	6660	R-303
55	J17	32.383	32.383	32.383	15.820	14.776	6583	R-304
56	J03	18.783	19.700	19.242	11.840	9.840	5455	R-304
57	K14	18.650	19.950	19.300	11.880	9.679	6649	R-304
58	J07	28.200	27.083	27.642	15.500	13.802	6518	R-304
59	D12	16.067	15.617	15.842	8.320	6.456	6102	R-304
60	K10	19.650	18.250	18.950	10.900	8.773	6487	R-304
61	W10	16.550	15.967	16.259	9.500	8.208	2805	R-304
62	K22	13.000	13.217	13.109	8.340	6.866	3371	R-304
63	U12	12.317	13.250	12.784	6.860	6.289	5225	R-304
64	S10	17.050	18.450	17.750	11.840	9.555	6735	R-304
65	P11	20.383	21.483	20.933	10.820	9.515	6720	R-304
66	T13	16.633	18.067	17.350	8.900	7.405	5961	R-304
67	Q12	16.983	15.767	16.375	10.800	8.996	6654	R-304
68	M10	17.233	17.500	17.367	12.400	10.153	5804	R-304
69	K08	27.283	27.117	27.200	17.520	16.110	6634	R-304
70	N13	17.583	18.883	18.233	12.880	10.146	6499	R-304
71	R13	16.700	17.317	17.009	9.320	8.639	6762	R-304
72	J11	14.367	14.433	14.400	8.016	7.054	6050	R-304
73	U10	16.383	15.333	15.858	10.820	8.885	5355	R-304
74	W12	7.500	7.633	7.567	4.480	3.560	3107	R-304
75	O12	15.583	16.633	16.108	9.620	8.441	6330	R-304
76	R11	18.550	18.583	18.567	12.180	10.273	6772	R-304
77	O10	17.517	16.833	17.175	9.060	8.339	6581	R-304
78	J15	16.233	16.867	16.550	9.240	8.389	6735	R-304
79	K18	18.283	18.633	18.458	12.940	10.942	6373	R-304
80	L09	21.467	20.367	20.917	13.740	12.035	6358	R-304
81	J05	20.750	21.283	21.017	14.940	13.113	6092	R-304
82	L13	14.683	14.800	14.742	10.100	9.012	6300	R-304
83	O14	19.783	19.867	19.825	11.780	9.659	6226	R-304
84	N11	23.083	23.567	23.325	12.620	9.925	5867	R-304
85	J01	15.417	15.867	15.642	9.700	8.427	3450	R-304
86	K20	20.150	19.683	19.917	12.820	10.985	5802	R-304
87	K16	22.817	23.750	23.284	12.920	11.914	6634	R-304
88	T11	19.317	19.117	19.217	11.200	9.333	6198	R-304
89	N09	20.833	20.667	20.750	11.060	10.040	6382	R-304
90	J13	20.500	20.533	20.517	11.720	10.408	6427	R-304
91	M14	12.733	13.567	13.150	9.080	7.845	6262	R-304
92	Q10	23.250	22.767	23.009	13.900	12.404	6520	R-304
93	K06	30.800	31.850	31.325	19.900	18.276	6130	R-304
94	P13	18.883	19.450	19.167	12.080	11.155	6613	R-304
95	S12	17.000	16.817	16.909	9.400	7.874	6648	R-304
96	J09	22.150	23.700	22.925	14.600	11.561	6507	R-304
97	S08	23.433	23.517	23.475	14.540	12.801	6327	R-304
98	J21	14.950	14.717	14.834	10.940	9.397	4489	R-304
99	T15	15.733	17.200	16.467	9.740	7.980	5697	R-304
100	K04	24.700	23.967	24.334	14.360	12.813	6299	R-304
101	M08	20.483	19.433	19.958	10.360	9.169	6181	R-304
102	H14	18.667	20.717	19.692	10.660	9.676	6583	R-304
103	N15	19.933	19.600	19.767	12.880	11.438	6631	R-304
104	P09	25.867	25.983	25.925	16.320	13.244	6290	R-304
105	G07	31.383	31.050	31.217	20.480	18.689	6168	R-304
106	Q14	17.333	17.450	17.392	11.080	9.787	6400	R-304
107	G17	27.550	29.100	28.325	16.120	14.680	5852	R-304
108	H10	23.683	24.617	24.150	14.720	12.042	6392	R-304

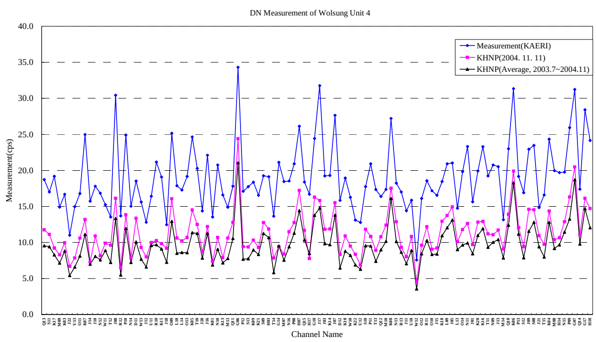

Fig. 1. Results of DN Measurements at Wolsung Unit 4.