Development of PHWR spent fuel transportation and dry storage management program

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1. Introduction

The management of the spent fuel DB basically begins with the manufacturing data of the nuclear fuel assembly, and in particular, the reactor operation history data is an important for evaluating the long-term integrity of the spent nuclear fuel. The operation history data in the nuclear reactor includes fuel assembly burn-up, EFPD, uranium content, enrichment, cooling time and power distribution that are important for evaluating the characteristics of spent nuclear. In this paper, the development of an automation program that evaluates the radioactivity of PHWR spent fuel is described based on operating history data.

2. Methodology and Program

The spent fuel generates various amounts of radioactivity and decay heat depending on the operation history, and gradually decreases over time. The analysis code used in this paper reflects the depletion history based on the express mode function of SCALE6.1's Origen-Arp system and evaluates the amount of radiation. ORIGEN 6.1 is used for the radioactivity evaluation and it is a module of the SCALE (Standardized Computer Analyses for Licensing Evaluation) [1]. Figure 1 shown below is a flow chart to evaluate the amount of radioactivity in PHWR SF.

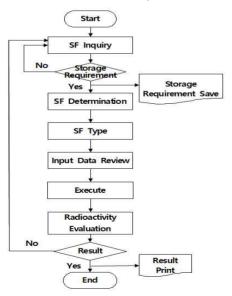


Fig. 1 Flow Chart of Radioactivity Evaluation

As shown in Figure 1, first, the SF stored in the spent fuel pool is inquired based on the discharge date and operation history of the PHWR SF. The SF is retrieved from the PHWR SF safety information system shown in Figure 2

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* III RP_AR_M2_M6_BAK		HOGI	SNO USNOG	U BATCHNAME	0 ORGN	U SUPPLY	BOXNO BOATE
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# PP_AR_M7_M8_M9_TMP # PP_AR_M786_65_73		2 3072	8907076 2	952-0903	17	ROOK	80090197 2009-09-24
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* III RP_NEWCR		8 10172	8907084 2	952-0903	17	3028	20090197 2009-09-24
* C RP.PL		9 10172	8907024 2	952-0903	17	302R	80090197 2009-09-24
# BP_REPORTMST		10 10172	8907087 2	952-0903	17	302R	80090197 2009-09-24
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* 🖾 TB.885.FILE		17 10252	8907052 2	\$52-0903	12	102R	BX090194 2009-09-24
* 🖾 18.00		18 10272	8907053 2	\$52-0903	37	1028	BX050154 2005-05-24
# TB.00.NEW	1	19 20172	8907054 2	\$52-0903	17	202R	20090154 2009-09-24
* TB_DD_NEW_BACKUP		AR cares			-		

Fig. 2 PHWR SF Information Management System

The PHWR SF safety information includes various information such as initial concentration, combustion, specific power, and discharge date. The PHWR SF management system finally selects spent fuel for dry storage or transportation based on the design requirements of the PHWR SF transportation and dry storage system. These are shown in Figure 3

CHNP		저장계통		운반용기						조회	
-		월성1호기		HI-STAR63 Hi-KORAD		1회자	2024-02-01	•	6刻자	2024-02-01	
0		월성2호기		운반횟수		2회자	2024-02-01		7회차	2024-02-01	
대상연료 조회		월성3호기 월성4호기		1 5 2 6 3 7	9 10	3회차	2024-02-01	U.	8회차	2024-02-01	
		i 일로(Silo)		4 8 냉각기간(년)		4회자	2024-02-01		9회차	2024-02-01	
저장연료 확정	맥스	터(MACSTOR)		10 ~		5회차	2024-02-01		10회자	2024-02-01	
	트레이번호	순번 연료번호	우라늄양	연소도	<u>ره</u>	순변	인료변호	우라늄	¦१ ।	견소도	
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	▼ 트레이 01▼ 트레이 02	V 1 FA01 V 2 FA02	20 20	4500		1	FA01	20	4500		

Fig. 3 Spent Fuel Selection of PHWR SF Management System

Figure 4 shows the configuration that code input data for evaluating the amount of radiation for fuel subject to transportation and dry storage.

KHN	저장계를		저동	(長円)		8292				
	사일로 먹스러 등등		82N	21		14WH				
-	계산모드	중성자그를	20	24		유민단위		3	년소주기 -	Libraries
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저장면료 확정			1	1	KX(1A39	2024.02.01	14WH	399268.0	21219	2541
	V 바스켓 01	60 2024.01.25	1	1	KK1C15	2024 02 01	14WH	401065.0	3.199	3186
	V 학주첫 01	60 2024.01.25	1	1	KK1E25	2024 02 01	14WH	400167.0	3,2179	3152
			1	1	KK1E29	2024.02.01	14WH	397347.0	3,2181	3202
	V 바스켓 02	60 2024.01.25	1	1	KK1E35	2024.02.01	14WH	399197.0	3,218	3177
			1	-1	KK1E36	2024.02.01	14WH	397787.0	32181	2677
	▼ 바스켓 03	60 2024.01.25	1	1	KK1E38	2024.02.01	14WH	399550,0	32181	3499
	1 1 1 2 7 03	00 2024.01.25	2	1	KKTY16	2024.02.01	14WH	361167.0	3.0021	4033
			2	1	KKTY19	2024.02.01	14WH	360844/0	3.8541	3975
	▼ 바스켓 06	60 2024.01.25	2	1	KK1Y20	2024.02.01	14WH	361236.0	3.8019	4035
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			3	1	KKTY17	2024.02.01	14WH	361152.0	3.8542	438
			3	1	KKTY29	2024.02.01	14WH	360159.0	3.8039	4452
			3	1	KK1Y36	2024.02.01	14WH	359823.0	3.8055	4498
			3	1	KKTY38	2024.02.01	14WH	360356.0	3.8376	4472
			4	1	KK1S34	2024.02.01	14WH	359516.0	3.8837	5031
			4	1	KKTY15	2024.02.01	14WH	361240.0	3 8549	4556
			4	1	KKTY27	2024.02.01	14WH	360570.0	3.8048	4591
			4	1	K0(1Y28	2024.02.01	14WH	360224.0	3.804	4616
			5	1	KK1W11	2024 02.01	14WH	360649.0	3,8015	5112
	10	실행	1							다운로드

PHWR SF

Figure 5 is a configuration showing the results of radioactivity evaluation for the selected SF. The evaluation results will be prepared in accordance with the KHNP's standard procedure form, which will be submitted to the Nuclear Safety Commission.

Standard (Operation Proce	dure 1030							
공균율력(M	1st연소기간(일)	1st명각기간(월)	2st평균문력(M.	2st연속기간(%)	2sti8각기간(앏)	3st랑귿움읙(M	3st연소기간(일)	방사능량(Ci/즙	방사능량(Ci/키
42.55	336.0							3.631E+04	2.2291E+00
48.51	461.0	39	33.59	454.0	31	21.14	461.0	1.854E+05	2.2291E+00
38.67	461.0	39	45.78	454.0	31	12.9	461.0	1.759E+05	2.2291E+00
37.94	429.0	38	35.98	461.0	1033	32.43	482.0	1.936E+05	2.2291E+00
47.74	424.0	81	39.45	449.0	50	15.09	473.0	1.516E+05	2.2291E+00
41.75	424.0	81	46.49	449.0	50	12.88	473.0	1.504E+05	2.2291E+00
42.83	424.0	81	46.84	449.0	50	12.88	473.0	1.519E+05	2.2291E+00
51.47	424.0	81	31.72	449.0	50	12.9	473.0	1.417E+05	2.2291E+00
41.3	270.0	74	48.01	275.0	76	21.6	242.0	9.183E+04	2.2291E+00
44.56	461.0	39	44.21	454.0	31	14.94	461.0	1.857E+05	2.2291E+00
45.52	270.0	74	48.06	275.0	76	17.23	242.0	1.075E+05	2.2291E+00
41.27	270.0	74	48.28	275.0	76	21.32	242.0	9.198E+04	2.2291E+00
42.56	336.0							3.615E+04	2.2291E+00
42.88	336.0							3.645E+04	2.2291E+00
40.46	336.0							3.452E+04	2.2291E+00
41.44	336.0							3.525E+04	2.2291E+00
42.16	336.0							3.564E+04	2.2291E+00
40.13	336.0							3.418E+04	2.2291E+00
40.67	336.0							3.444E+04	2.2291E+00
41.4	270.0	74	48,62	275.0	76	21.59	242.0	9.217E+04	2.2291E+00
34.43	460.0	37	45.39	508.0	29	14.02	496.2	2.265E+05	2.2291E+00
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Fig. 4 Radiation Evaluation Result Form of PHWR SF Management System

3. Result and Conclusions

In this paper, A system was constructed to automate the evaluation of the amount of radioactivity performed during the transportation or dry storage of spent nuclear fuel in PHWR. This system basically fetches the manufacturing and output history of nuclear fuel used in heavy water from the heavy water reactor safety information system and is used to evaluate the amount of radioactivity. Therefore, it is expected that errors caused by human errors can be minimized and the time required for evaluating the amount of radiation can be significantly reduced.

REFERENCES

[1] Scale. A Comprehensive Modeling and Simulat ion Suite for Nuclear Safety Analysis and Design, Version 6.1.3, 2015.

[2] NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities", Final Report, U.S. Nuclear Regulatory Commission, 2020.