Simulation of Release Inventories of Primary Nuclides from PIE in Hotcell

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1. Introduction

IMEF(Irradiated Material Examination Facility) was established for hotcell test with irradiated fuels and materials. There is safety regulation of RMS(Radiation Monitoring System) for radioactive nuclides generated in hotcell[1,2]. In this paper, H-3, I-131, I-129, Kr-85 and Xe-133 are considered, which are important nuclides in RMS. RMS chamber for tritium, Iodine and noble gases have been checked periodically. Whenever detecting signal of these nuclides occurs in RMS, The facility has been reported to know reasonable events. Therefore, the nuclides above are investigated from generation to release in the air in this study.

2. Methods and Results

This study depends on calculation and simulation of isotope generation in fuel. ORIGEN code in SCALE 6.2 has been well-known so far and was used to calculate isotope generation from fuels[3,4].

2.1 Assumptions

PIE in hotcell has been carried out with various fuels irradiated in Hanaro Rx, e.g. metallic fuel(U-Zr), ceramic fuel(UO_2), fuel particle(TRISO) and dispersed fuel(U-Mo,Al), etc. ORIGEN code is limited to UO_2 and MOX in LWR and PHWR, then first assumption is that UO_2 in PWR standard condition is adapted in this calculation for isotope generation. Second assumption is that DUP system for air filtration is only considered without other air filtration system in IMEF as shown in Fig.1. The case of release of the isotopes from fuel occurs only rod-cutting, then number of cutting event is third assumption.

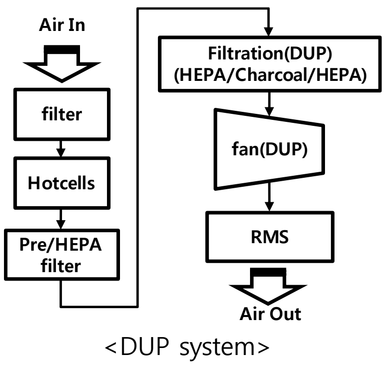

Fig. 1 Air flow in DUP system

In this case, all nuclides released from fuel cutting events in hotcell have been captured in DUP filtration except noble gases and tritium.

2.2 Code calculation

ORIGEN input was shown in Table.1 and fuel assembly type(Ce 16x16) is similar to several NPPs in country[4].

Table 1 ORIGEN input

Input items	*value*
PWR type	Ce 16x16
Fuel comp.	UO_2
Fuel rod Active length(mm)	381
Burup(Gwd/MTU)	40
Power/rod(MW)	37.035
No. of Cycle	3
Days/cycle	540

Neutron and gamma libraries are applied in Scale 6.2 and other properties are used in the code.

2.3 decay results

Cooling times are 0.1 ~ 10 years and activities of the nuclides are shown in Fig. 2 and I-131 and Xe-133 seemed to be vanish in 1 year. Kr-85 and H-3 still keep steady behavior and certain difference between them was exist.

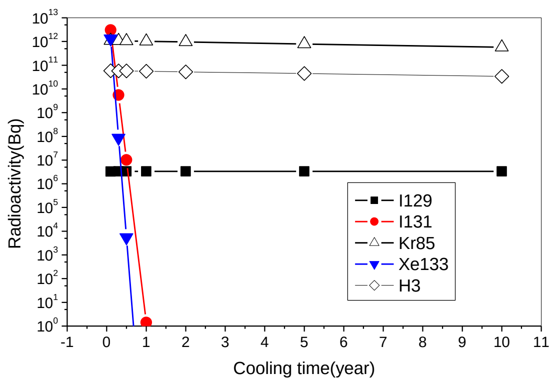

Fig. 2 Decay behavior of nuclides until 10 years of cooling time based on ORIGEN calculation

Recently, all fuels in IMEF have been stored in hotcells for more than 5 years. I-131 and Xe-133 would not exist in fuels any more, then might not be monitored by RMS. Rest of nuclides were calculated how amount of release to RMS by air flow through DUP system. When fuel rod cutting is carried out, I-129, Kr-85 and H-3 have released to hotcell, then cutting gap and cutting number must be decided to calculate release amounts. I-129 would be captured by DUP filtration. It was assumed cutting gap is 5 mm including grinding/polishing process and 10 times of cutting events would be carried out to know amounts of Kr-85 and H-3 released. Ratio of total cutting gap to total active length of fuel rod is 0.01312(50mm/3,810mm).

2.4 Calculation of air-flow with Krypton and tritium

It is assumed fuel rod cuttings were performed by 10 events per month and Kr-85 and H-3 are released to RMS. Air flow rate of DUP fan is 15,840,000 m^3 per month(22,000 m^3/h x 24 hours x 30 days)[5].

Released amounts of Kr-85 and H-3 were adapted to air flow rate of DUP system, then those results are shown in Fig. 3. Concentration(Bq/m^3) of Kr-85 is always higher than that of H-3 by 18~20 times as well as radioactivity of it.

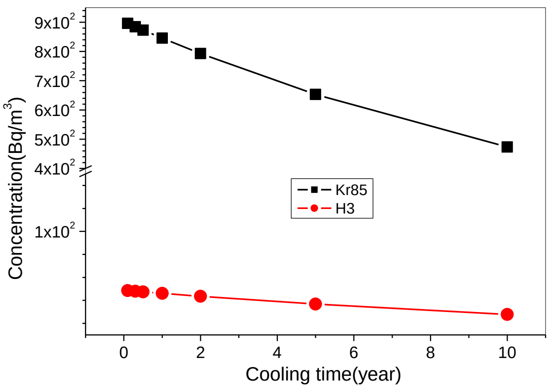

Fig. 3 Concentration of Kr-85 and H-3 in DUP system

Maximum release amounts per year of nuclides were listed in Safety analysis Report as 2.23×10^{12} Bq for H-3 and 4.0×10^{13} Bq for Kr-85, respectively[1]. Those values were higher than results in this study by 2 orders.

The results of concentrations in fig.3 were very lower than those in alarm-setting of RMS. It means PIE for fuels in this facility has been agreed to regulation of Radiation safety in according to calculation results and assumptions in this study.

3. Conclusions

IMEF has been examined various fuels for R/D, then isotope generation in fuel is very important to estimate shielding problem and radioactive waste calculation as source term. However, recently, ORIGEN code(Scale 6.2) is not applicable to every type of R/D fuel. However, the code is still useful to calculate isotope generation in ceramic fuel. In this study, the purpose is the simulation of release amounts of some radioactive nuclides during fuel rod cutting events in hotcell as well as comparison to each other. Many assumptions were applied and unknown factors still exist in this study. Nonetheless, gaseous nuclides and iodine must be traced to agree the safety regulation in the hotcell facility. Estimation of the source term and the release event during PIE must be considered to agree the RMS control[2].

REFERENCES

[1] Hanaro Safety Analysis Report, Chap. 11.4(Irradiated Material Examination Facility)
[2] Procedure Report of RMS(RSC-monitoring document)
[3] B. T. Rearden, M. A. Jessee, Scale Code System, ORNL/TM-2005/39.
[4] I. C. Gauld, O. W. Hermann, R. M. Westfall, ORIGEN-S: Scale System Module to Calculate Fuel Depletion, Actinide Transmutation, Fission Product Buildup and Decay, and Associated Radiation Source Terms, NUREG/CR-0200, Revision 7, Vol. 2, Section F7, 2002.
[5] Procedure Report of The Operation/Maintenance of the IMEF Ventilation system(IMEF-OP-01-01)