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Comparative Analysis on the Source Term of Spent Fuel Using SCALE 5.1 and SCALE 6.1 Versions

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1. Introduction

Establishment of the radionuclide inventory status of spent nuclear fuel (SNF) before packaging and transportation is a regulatory requirement as enshrined in Article 72 of the Korean Act [1]. That is, total radioactivity of spent fuels has to be calculated in advance before transport in accordance with regulation requirement. Regulatory body also calculates the source term of the spent fuel to verify the applicant's calculation results.

Dae-sik Yook et.al [1] compared calculations performed by ORIGEN-ARP of SCALE 5.1 with ARP-AUTO of SCALE 6.0 using the same input parameters to determine the radionuclide inventory status of SNF from Kori, Hanbit, Hanul, and Wolsong sites. The results showed differences between the calculations performed by the two versions of the computer code. According to the previous study, applicant used SCALE 5.1 and reviewer used SCALE 6.0. There were some different evaluation results and the range of relative error was about 0.9 ~ 3.0%. This might have been caused by the difference of data libraries between SCALE 5.1 and SCALE 6.0[1]. The aim of this study is to compare calculation results by using the ORIGEN-ARP of various version of SCALE code package. Through this, it is to find the reason of difference of evaluation result between the applicant and regulatory body.

2. Methodology

In this section, a selection of the representative spent fuel in Korea, computer codes, input parameters, and methods are described. In Korea, nuclear fuel of PWR can be categorized as Westinghouse type (Fuel type: WH17X17_ofa in ORIGEN_ARP) and Combustion engineering (Fuel type: CE 16X16 in ORIGEN_ARP). In case of PHWR, fuel type was selected as CANDU_37 for ORIGEN_ARP. And the versions of ORIGEN code selected were 5.1 and 6.1 because they are widely used in nuclear industry for the calculation of source terms of spent fuel. Every input parameter in each case is selected by considering real cases as follows;

2.1 Assumption of input parameters

2.1.1 Input parameters.

Reactor type	PWR		CANDU
Fuel type	W17x17_ofa	CE16x16	CANDU 37
Enrichment (%)	3.5	5.0	0.711
U (g)	420,000	300,000	19,200
Burnup (MWd/MTU)	70,000	50,000	7,500
Cooling Time (years)	6	6	6
Avr. Power (MW/MTU)	127.85	91.32	13.7

2.1.2 Cases.

SCALE version	Neutron Group	Gamma Group	Cases
5.1	27GrpENDF5 44GrpENDF4 47GrpBUGLE 218GrpENDF4 227GrpENDF5 238GrpENDF5	18GrpSCALE 20GrpBUGLE 44GrpENDF5	6x3=18 Cases
6.1	200GrpENDF6	47GrpENDF6	1 Case
Total			19 Cases

2.2 Methods

By using the same input parameters, 19 cases with combination of neutron energy group and gamma energy group were chosen and in each case calculation was performed to find the reason for different results obtained by the applicant and the reviewer. ORIGEN-ARP in SCALE 6.1 contains all energy groups including that of the previous versions. But the output format is slightly changed and most of all, because the difference in the calculation results in the previous study [1] might have come from different energy groups and/or different version of ORIGEN-ARP. ORIGEN-ARP in different version of SCALE code was used in this study. If the calculation results with different energy groups differ from each other in each case, certain difference among the calculations is expected which may serve as tolerance depending on the error magnitude. this may occur as a result selecting different energy groups by the applicant and the reviewer. In the opposite case, input parameters between applicant and reviewer may differ slightly.

3. Results

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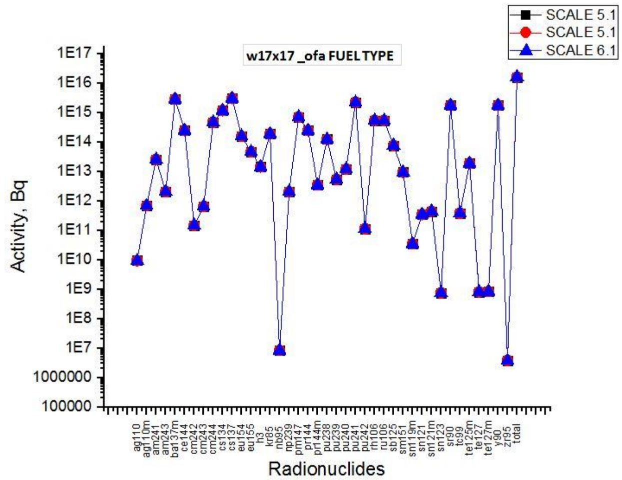

Fig.1. Activities of Radionuclides of w17x17_ofa SNF

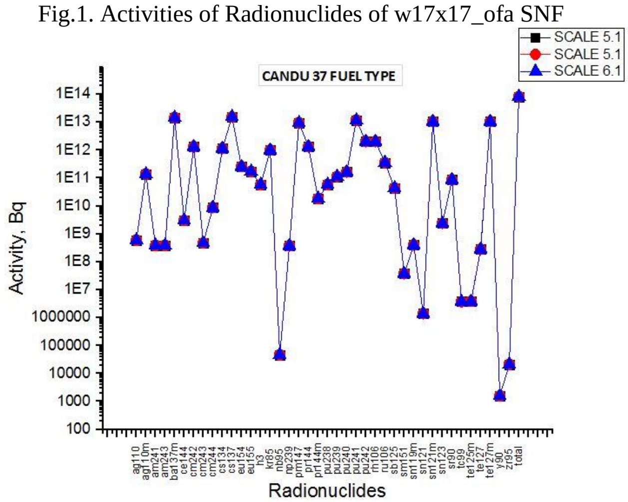

Fig.2. Activities of Radionuclides of CANDU37 SNF

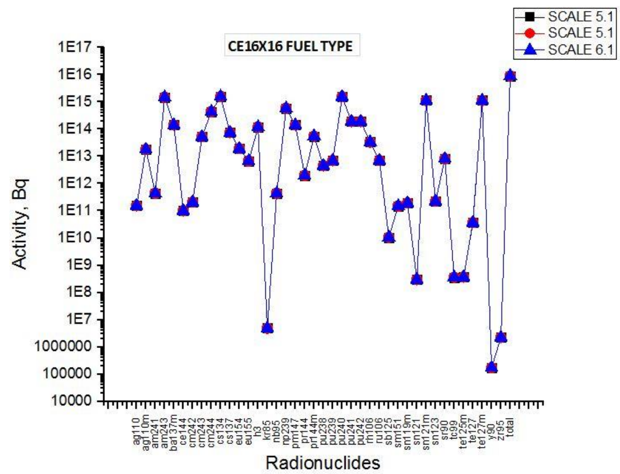

Fig. 3. Activities of Radionuclides of CE16x16 SNF

4. Conclusions

When source terms of spent fuel are calculated by ORIGEN-ARP, different energy groups cannot affect the calculation results as shown in Figures 1, -2, and -3. That is, calculation results of the same input parameters are always the same even by selecting different energy groups. This is not the expected result, because ORIGEN-ARP provides change options of neutron/gamma energy groups. Certain difference between the results was expected. As a result, it is suggested that the applicant should describe all assumptions and input parameters in detail when calculating source terms of spent fuel using ORINGE-ARP regardless of SCALE code version. This is done in advance before the applicant applies to the regulatory body for the transport of spent fuel. And when the applicant's calculation results are being reviewed by the regulatory body, the assumptions and input parameters should be scrutinized to ensure that they are proper. This is because the calculation results are always expected to be the same if the same input parameters are used regardless of energy group (Neutron, Gamma).

In a situation where the reviewer's result differs from that of the applicant's, the applicant should provide satisfactory explanation, otherwise the document should be returned for resubmission.

REFERENCES

[1] Dae-sik Yook, et al. Development of the Computer Code for Multi-Calculations of Source Term of Spent Fuel-1535. WM2015 Conference, Phoenix, Arizona, USA. March 15-19, 2015

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[4] SCALE 5.1 OrigenARP user manual.

[5] SCALE6.1 OrigenARP user manual