The possible use of short half-life noble gas fission products for measurement of criticality and identification of plutonium in fuel debris canister

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Fuel debris has inherent neutron sources due to mostly spontaneous fissions. Therefore, the fuel debris inside a canister can be seen as a subcritical system with fixed neutron sources. A depletion calculation for the fuel debris (FD) inside the canister has been performed. The calculation results show the activity ratio of ^{88}Kr-to-^{135}Xe in the fuel debris canister depending on the material compositions and effective neutron multiplication factor (k_{eff}).

Keywords: Depletion Calculation, Subcritical System, Fuel Debris Canister, Mixed Oxide (MOX) Fuel, Monte Carlo Calculation, Short Half-life Fission Products

1. Introduction

In this study, we performed neutron transport and subcritical depletion calculations for the canister filled with fuel debris using the modified OpenMC code version 0.11 [1]. The calculation considering the FP generations by spontaneous and induced fissions provides the information on the criticality of the canister and the amount of plutonium in the canister from the difference of the activity ratio ^{88}Kr-to-^{135}Xe.

2. Calculation Method and Results

The time-dependent FP production behavior of fuel debris in a canister will be determined by radioactive decay, spontaneous fission and its subsequent induced fission. We performed burnup calculations for the canister filled with fuel debris with different burnup degrees from Unit 1, Unit 2 and Unit 3 of the Fukushima-Daiichi NPP by using the OpenMC code modified in the previous work [2]. We have obtained the relationship between the activity ratio of ^{88}Kr-to-^{135}Xe and k_{eff} as shown in Figure 1. The activity ratio of ^{88}Kr-to-^{135}Xe also provides us the information on whether the fuel debris is originally UO_2 or MOX and the magnitude of the burnup degree.

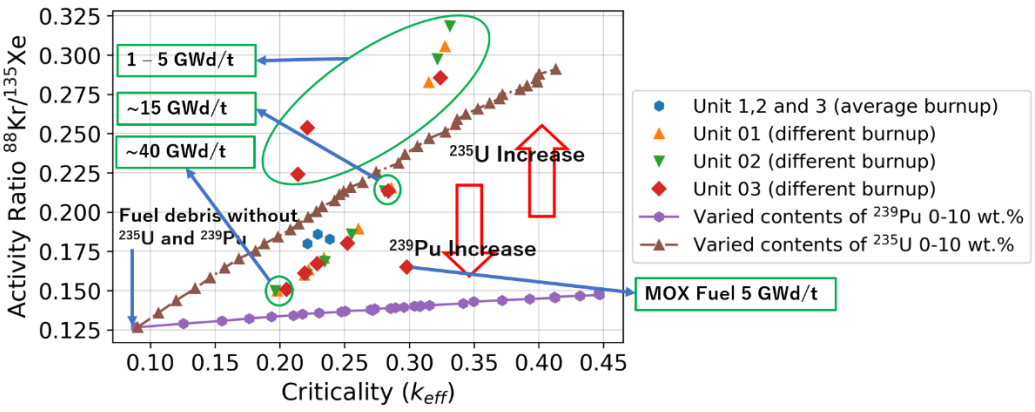

Fig. 1. Activity ratio of ^{88}Kr/^{135}Xe versus k_{eff} for various fuel debris in canister

3. Conclusion

Combined neutron transport and depletion calculations were performed for the canister filled with fuel debris with different burnup degree using the modified OpenMC code. The calculation result showed the relationship between the activity ratio of ^{88}Kr-to-^{135}Xe and the effective neutron multiplication factor (k_{eff}) and the possibility to identify the origin of the fuel debris by the activity ratio of ^{88}Kr-to-^{135}Xe.

References: [1] Paul K. Romano, et al., Ann. Nucl. Energy. 2015; 82: 90–97. [2] Eka S. Riyana, et al., Atomic Energy Society of Japan 2021 Annual Meeting, 17 – 19 March 2021.