Evaluation of Preliminary Criticality Safety for Metal Storage Cask

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1. Introduction

The purpose of this analysis is to identify the criticality margin for the metal storage cask. The metal storage cask assumed that 32 spent fuel assemblies could be stored and considered the worst conditions. The criticality evaluation was carried out applying burnup credit effect according to SFST-ISG-8(Re.3). And the reduction of the reactivity according to the cooling period was also considered.[1]

2. Modeling Approach and Assumptions

2.1 Spent Nuclear Fuel

The spent fuel data applied to the analysis are as follows.

- Fuel Type : 17x17 WH V5H
- Enrichment : 2.0 ~ 4.5wt%
- Burnup : 0 ~ 45,000MWd/MTU
- Cooling : 5 year
- Axial Burnup : NUREG/CR-6801 Profiles[2]

2.2 Storage Cask

Specifications of the storage cask used to the analysis are as follows and modeled as Figure 1.

- Number of Stored Fuels : 32 assemblies
- Canister ID/OD : 163.6/168.6 ㎝
- Cask ID/OD : 169.6/212.6 ㎝
- Neutron Absorber
  - Thickness : 0.3 ㎝
  - B-10 Areal Density : 0.0317732 g/㎠

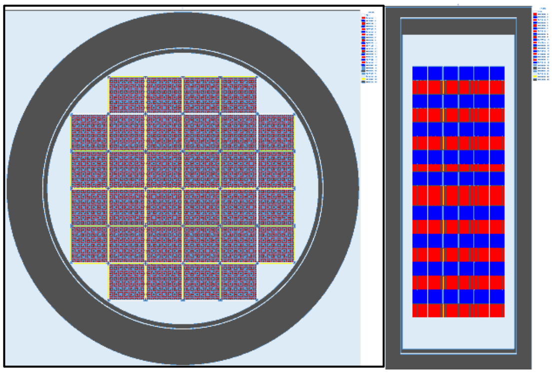

Fig. 1. Analysis model.

2.3 Computer Codes, Cross Section Library

For this analysis, SCALE 6.1 and the 238-group ENDF/B-VII cross section library was used. SCALE 6.1 is the most recent release of the SCALE code system which has been heavily used throughout the world for criticality analysis. The SCALE code system is a series of modules run by sequence drivers. For this work, TRITON sequence was used for depletion and CSAS5 sequence was used for calculation of k_{eff}.[3]

2.4 Applied Set of Nuclides

28 nuclides set was applied for burnup credit as Table 1.

Table 1. Applied set of nuclides for burnup credit

Nuclides			
^{234}U	^{235}U	^{238}U	^{238}Pu
^{239}Pu	^{240}Pu	^{241}Pu	^{242}Pu
^{241}Am	^{95}Mo	^{99}Tc	^{101}Ru
^{103}Rh	^{109}Ag	^{133}Cs	^{147}Sm
^{149}Sm	^{150}Sm	^{151}Sm	^{152}Sm
^{143}Nd	^{145}Nd	^{151}Eu	^{153}Eu
^{155}Gd	^{236}U	^{243}Am	^{237}Np

2.5 Code Validation – Isotopic Depletion

The depletion bias uncertainty was applied as a function of assembly average burnup(Table 2) according to SFST-ISG-8(Re.3).

Table 2. Isotopic uncertainty for burnup range

Burnup Range (GWd/MTU)	Isotopic uncertainty
0-5	0.0150
5-10	0.0148
10-18	0.0157
18-25	0.0154
25-30	0.0161
30-40	0.0163
40-45	0.0205
45-50	0.0219
50-60	0.0300

2.6 Code Validation − K_{eff} Determination

According to SFST-ISG-8(Re.3), if 28 nuclides set was applied for burnup credit as Table 1, 1.5% of the worth of the minor actinides and fission products conservatively covers the bias.

3. Analysis Result

The result of preliminary criticality safety analysis shows that initial enrichment less than 2.0wt% fuel can be stored without burn. 4.5wt% fuel can be stored burnup more than 36,000MWd/MTU. The loading curve is shown in Figure 2.

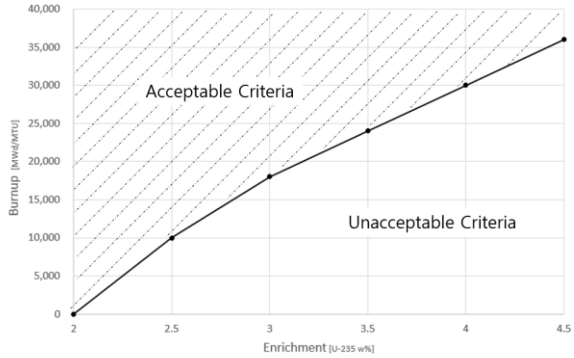

Fig. 2. The loading curve.

4. Conclusion

Evaluation was performed to identify critical margins for the metal storage cask. The cask assumed the worst conditions and the critical evaluation was based on the burnup credit. The result of preliminary criticality safety analysis shows that the critical margin was larger than expected.

REFERENCES

[1] Division of Spent Fuel Storage and Transportation Interim Staff Guidance - 8, Revision 3 - Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transportation and Storage Casks, 2012.

[2] J.C. Wagner, M. D. DeHart, and, C. V. Parks, Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses, US NRC, NUREG/CR-6801, Oak Ridge National Laboratory, 2003.

[3] Scale. A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design, Version 6.1, 2011.