Sensitivity Evaluation for Decay Heat Calculation Method of Spent Nuclear Fuel in the SFP

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1. Introduction

The spent nuclear fuel storage pool (SFP) is a facility for storing spent nuclear fuel. The decay heat in an SFP is generated in the spent fuel assemblies stored therein. Due to the exponential nature of radioactive decay, the heat of the fuel assemblies in an SFP will, therefore, be constantly reducing with time.

In order to conservatively simplify the decay heat calculations, the total decay heat is considered as coming from two different groups of assemblies. One is fuel assemblies from previous offloads already stored in the SFP, and the other is fuel assemblies that are being offloaded from the reactor to the SFP. In first group are relatively short transient evaluation period of the heat generation rate of these assemblies reduces very slowly with time, due to the exponential nature of radioactive decay and their relatively long decay periods. The decay heat contribution of these assemblies can therefore be conservatively treated as constant, neglecting any reduction in their decay heat contribution during the evaluation period. In second group's heat generation rate of these assemblies reduces rapidly with time, so decay heat contribution of these assemblies is treated as time varying. The decay heat contributions of both the previous offloaded and recently offloaded fuel are usually calculated using the methodology of ASB 9-1[1] or ANSI/ANS-5.1[2]. In this study, decay heats for nominalized fuel of normal scenarios using the ASB 9-1 and ANSI/ANS-5.1 are compared.

2. Methods and Results

Total time-varying decay heat generation rate in SFP is calculated from decay heat of previous offloaded fuel and recently offloaded fuel with heat removal from heat exchangers of an SFP. The transient thermal response of an SFP and an SFP cooling system to thermal loads is governed by the following equation:

$$Q_{pool} = Q_{previou} + Q_{recent} - Q_{SFPCS}$$

Heat removal from the SFPCS is a nonlinear function of the bulk temperature and the cooling water temperature with heat exchanger performance.

Fig. 1 shows the decay heat evaluation results over time for normal conditions. Under the same conditions, the ANSI/ANS 5.1 methodology was evaluated to have a higher decay heat than the ASB 9-2 methodology. These results can be explained through Fig. 2, which is the result of evaluating the decay heat of spent nuclear fuel over time. The results of the ANS 5.1 and the ASB 9-2 do not differ significantly in terms of trends when compared across the entire time period. However, the period of greatest influence in the calculation of the decay heat of SF stored in SFP is between 10 to the 5th power second and 7th power second shown in Fig. 2. The decay heat in this part appears larger in the ANS 5.1. Therefore, considering that more than 150 assemblies of fuel are discharged in the reloading operation, the difference appears large as shown in Fig. 1.

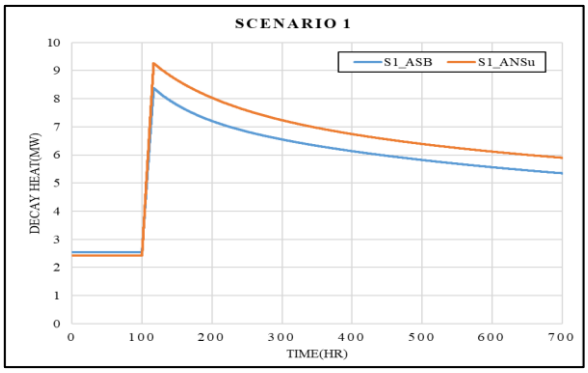

Fig. 1. Total Decay Heat of SFP over Time

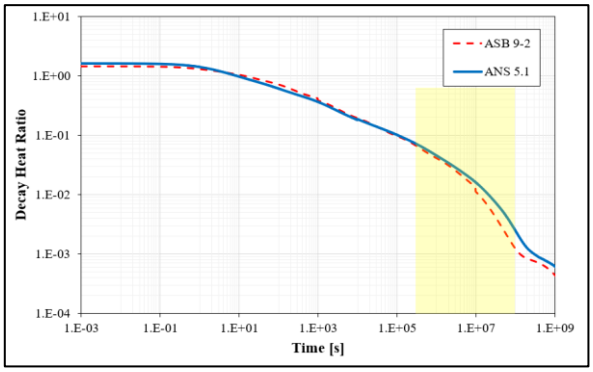

Fig. 2. Decay Heat of Spent Nuclear Fuel over Time

3. Conclusions

It was confirmed that the ANS 5.1 method showed more conservative results in terms of decay heat than the ASB 9-2 method. However, this result is because the fraction of fission products was conservatively applied in ANS 5.1, and more realistic and reasonable results could be obtained if clearer data were used.

REFERENCES

[1] "Decay Heat Power in Light Water Reactors," ANSI/ANS-5.1-2014, American Nuclear Society, La Grange Park, IL (2014).

[2] "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," NUREG-0800, Rev. 2, Sec. 9.2.5, "Ultimate Heat Sink," Branch Technical Position ASB 9-2, "Residual Decay Energy for Light-Water Reactors for Long-Term Cooling," U.S. Nuclear Regulatory Commission.