The Constructing Status and Preliminary Evaluation for the Criticality Safety Design of Okuma Analysis and Research Center

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1. Introduction

According to “Mid-and-Long-Term Roadmap” established by the Inter-Ministerial Council for Contaminated Water and Decommissioning Issues, constructing the analysis facility to clarify the prospects of treatment and disposal methods and technologies regarding the safety of radioactive materials is requested. Japan Atomic Energy Agency (JAEA) is constructing Okuma Analysis and Research Center as the facility it is requested on “Mid-and-Long-Term Roadmap”.

JAEA has established a cooperative relationship with Tokyo Electric Power Company Holdings (TEPCO) for decommissioning of Fukushima Daiichi Nuclear Power Station (Fukushima Daiichi). Specifically, JAEA analyze the fuel debris removed from Fukushima Daiichi. At Okuma Analysis Research Center, the fuel debris are handled as the analysis samples. Therefore, the evaluation of the critical mass limit of the fuel debris is necessary as a preliminary study of the criticality safety. And consideration of the criticality safety control method of Okuma Analysis and Research Center will be requested.

This report explains the constructing status of Okuma Analysis and Research Center and the preliminary evaluation of criticality safety.

2. The status of Okuma Analysis and Research Center

Okuma Analysis and Research Center consists of one office building and two radioactive material analysis facilities.

- Administration building : It provides office space, meeting rooms for researchers, and apparatus mock-up. (Start operation in March 2018)
- Laboratory-1 : The scope of this laboratory is radioactive analysis of low and medium level radioactive rubbles and secondary wastes. (Under construction)
- Laboratory-2 : This facility is designing as dedicated hot laboratory for radioactive analysis, and mechanical and chemical characterization of fuel debris. (Under design)

Figure 1. Okuma Analysis and Research center (Left) and Location (Right).

Figure 2. Administrative building (left), Laboratory-1 (under constructing) (right)

3. The preliminary criticality safety evaluation of Laboratory-2

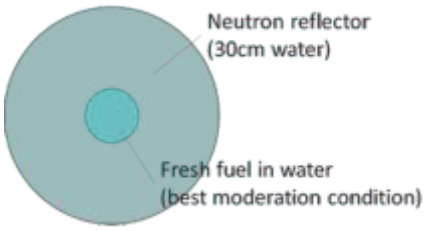

Figure 3 The Critically safety evaluation model

The fuel debris are handled in Laboratory-2 as the chemical and mechanical analysis samples, but their basic and important parameters for the criticality safety evaluation such as "shape", "density" and "composition" are not clear. For this reason, the criticality safety evaluation model of the fuel debris (Fig 3.) must be independent of these parameter. Since the basic parameters are not clear, the best moderation condition is applied to the fresh fuel set at center of the model. The best moderation condition is the most conservative volume ratio of moderator (water) to fissile material. And the fuel is surrounded by the neutron reflector (30 cm thick water layer).

Since Laboratory-2 handle only the fuel debris as nuclear material, the criticality safety evaluations are performed assuming only Fukushima Daiichi fuel (fresh fuel) as fuel debris. The two types fuel (Uranium fuel and MOX fuel) were loaded in Fukushima Daiichi unit-3, and they were mixed on the process of core-meltdown. It is necessary to evaluate the mixture of different type fuels. In the evaluation, the effective multiplication factor (keff) of 12 kg fuel debris was obtained with changing the uranium fuel ratio as a parameter. As a result of evaluation, it was cleared that performing critical evaluation with pure MOX fuel is the most conservative. (Fig 4). The relationship of keff ratio and percentage of Uranium fuel. Another evaluation is performed to obtain the critical mass limit of MOX fuel, and it has been clarified. This result has been cleared that handling 5 kg fuel debris is concluded to be feasible even if double batches are considered.

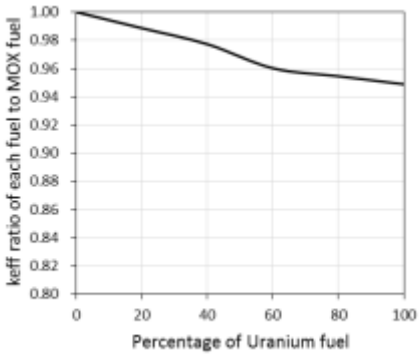

Figure 4 The relationship of keff ratio and percentage of Uranium fuel

4. Summary and future work

As a result of preliminary criticality safety evaluation, it was cleared that using pure MOX fuel as the fuel debris is the most conservative on the criticality safety evaluation. From the result of evaluation, it was shown that 5 kg fuel debris are safely handled in Laboratory-2.

As the future work, the feasibility of criticality safety control method in consideration of the analysis operations of the fuel debris in Laboratory-2 will be confirmed.