Stepwise Approach on Spent Nuclear Fuel Integrity Evaluation R&D Work in Korea

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1. Introduction

The national plan on SNF management was announced by MOTIE in 2016. Dry storage business will be visualized after the relevant Act is approved soon. Safety evaluation on our domestic SNF is essential work in order to support the success of this coming business. Review on USA case, especially dividing burnup range, is very useful to establish our R&D strategy for the long time frame. The review result recommends that a stepwise approach on burnup range with low and high is desirable in Korean case.

2. Status of SNF Management

2.1 National Basic Plan by MOTIE

MOTIE (Ministry of Trade, Industry, and Energy) which is in charge of nuclear promotion and also radioactive waste management announced the Basic Plan of High-Level Radioactive Waste Management [1] and AEC (Atomic Energy Commission) approved the plan in 2016. Based on this plan, Storage, transportation and disposal business of spent nuclear fuel could be more tangible and implemented just after the relevant Act which is now tentative and waiting for Congress approval.

2.2 Urgency in storage business

SNF inventory database of KHNP (Korea Hydro and Nuclear Power) indicated that unloading PWR SNF from pool to dry storage should be started at least 2024 and 80% of SNF belong to the lower burnup level (less than 45 GWd/MtU) [2].

2.3 Importance of SNF integrity

Lessons learned [3] from foreign predecessors shows us the importance of SNF integrity evaluation because storage time frame is getting longer without visible disposal progress, there is almost no more chance to check SNF condition after the initial loading into the first dry storage, and uncertainty of SNF status after several decades storage could be a huge threat to SNF delivery from utility to the government, to long distance transportation and to safe handling before disposal packaging.

3. Reference on burnup consideration

A EPRI report [4] picture (Fig. 1) shows SNF cladding material degradation along burnup level. Data tendency in low burnup level (less than 45 GWd/MtU inside #2 line area) is easily predictable, however in high burnup range (from #2 to #4 line area), data dispersion & deviation is getting more significant along burnup increase. Regulatory history in USA has experience of two step approach on burnup range. Regarding to urgent PWR SNF dry storage, it is necessary to consider stepwise approach on R&D.

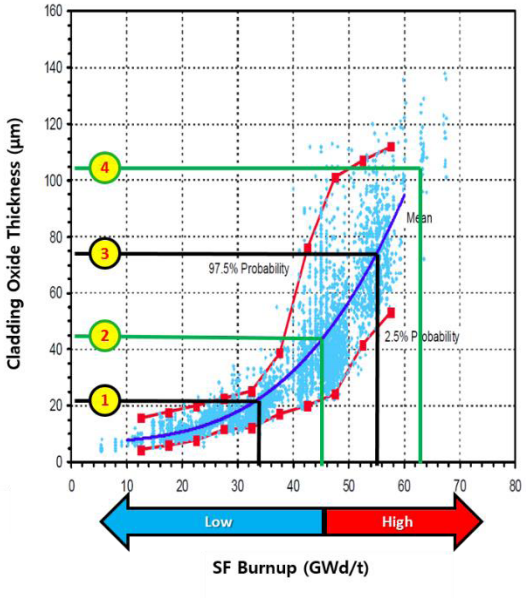

Fig. 1. SNF burnup vs cladding oxidation.

3.1 Low Burnup

SNF testing data in PNNL (Pacific Northwest National Lab.) before 1985 when the first commercial dry storage was started was concentrated on 33 GWd/MtU range with 45 GWd/MtU maximum data (Fig. 2) [5]. This means that majority of #1 data covers up to #2 area even though material degradation tendency is getting severe along burnup increase.

Type of Operating Conditions	Fuel Design	Rod-Average Burnup, MWd/kgM	Rod Pressure, psi
Upper Bound Operating Conditions	PWR 15 x 15	33	1707
		45	2416
	BWR 7 x 7	28	1094
Average Operating Conditions	PWR 17 x 17	33	1293
	BWR 8 x 8R	28	142

Fig. 2. USA Low Burnup SNF testing in 1980's.

3.2 High Burnup

The first high burnup SNF dry storage license with 20 years in USA will be expired in 2025, however SNF testing data in high burnup range is precious because hotcell work in laboratories is getting difficult with many reasons even though data dispersion is huge in this area. In order to support above license renewal, 'High Burnup Demo' by US DOE and EPRI [6] utilizes around 54 GWd/MtU level (#3) SNF and tries to cover up to #4 area. A recent research result [7] on SNF inventory in USA shows the majority of high burnup SNF is near #3 line area and this raises the justification of the Demo work.

4. Stepwise Approach on R&D

4.1 Low Burnup

The ongoing research program funded by MOTIE is now focusing on low burnup range first because low burnup SNF occupies the majority of PWR SNF inventory and Korea needs to improve R&D infra which is dedicated on SNF testing and evaluation technique. In this framework, the 'fast follower' strategy is adapted and the main target of R&D is to verify whether our domestic SNF testing data satisfy the already well-organized regulatory requirements or not. If there are some extreme results, then we need to establish our own strategy to treat those SNFs.

4.2 High Burnup

Most concern about high burnup SNF is 'transportability' after several decades storage. Material degradation according to decreasing temperature in storage system could cause brittle condition and mechanical integrity with this embrittled material(especially cladding) is not secured at impact situations like fuel handling, transportation and repackaging. No one has experience mentioned above and that is why high burnup remains a big problem. Infra structure established and verified with low burnup range could be expanded to high burnup range and it is expected to produce reliable SNF testing data with various cladding materials.

5. Conclusion

The national SNF management plan has been announced in 2016 and this could construct a strong cornerstone which supports storage business and research work on SNF. A Stepwise approach on PWR SNF R&D by dividing low and high burnup area is reasonable in considering urgency of storage and infra structure of R&D.

ACKNOWLEDGEMENT

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