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Characteristic Inspection Plan for PWR Spent Fuel Dry Storage

Donghee Lee*, Yongdeog Kim, Kiyoung Kim
Korea Hydro and Nuclear Power Co. LTD, Central Research Institute
1312-70 Yuseon-daero, Yuseong-gu Deajeon, 305-380, Korea
*Corresponding author: donghee.lee@khnp.co.kr

1. Introduction

In 2016, the government announced the basic plan of HLW management to construct on-site spent fuel (SF) dry storage facilities in NPP sites. First of all, it is urgent to construct the SF dry storage facilities for securing the fuel storage capacity of Hanbit NPP site and decommissioning Kori unit 1. Because the fuel integrity must be maintained during dry storage, it is necessary to inspect and confirm the defects of fuel before transferring to the dry storage facility. Once the fuel is stored in the dry storage systems, it is difficult to inspect the fuel. So KHNP has a plan to inspect the spent fuel before loading it into the dry storage system to verify the requirements for dry storage licenses and delivery to KORAD. For this purpose, KHNP will perform the project to evaluate the characteristics of the spent fuel.

2. Pool Side Examination (PSE) [2,3]

It is important to inspect the characteristics of spent fuel in a spent fuel pool before loading it into the dry storage system because the initial characterization of the spent fuel is essential for the evaluation of the retrievability of the spent fuel.

The behavior and characteristics of the spent fuel can be confirmed through Pool Side Examination (PSE) performance. Generally, the PSE includes the visual examination and measurement of several characteristics, such as fuel assembly length, fuel assembly bow & twist, rod & shoulder gap, grid width, rod diameter and oxide thickness. In what follows, we provide a brief introduction to each test. Figure 1 shows the Schematic diagram of PSE examination

2.1 Visual Examination

Visual examination provides a first impression of the fuel condition, and can be to identify the mechanical integrity of fuel assembly including its structural components. For the visual examination is high resolution underwater cameras with the appropriate light systems are installed on the X-Y inspection table.

2.2 Fuel Assembly Length

Length of fuel assembly measurement can be checked with the camera installed on the XYZ table. Length measurement is applied for four faces of the assembly. Rod length is obtained from the distance between the upper fuel rod and the lower top nozzle.

2.3 Fuel Assembly Bow & Twist

The assembly bowing is defined as the deviation of the assembly centerline from the line between top and bottom nozzle. In case the assembly is bowed, some different distances of the plumb line to the assembly are measured by means of the camera and video micrometer.

2.4 Rod & Shoulder Gap

Rod & shoulder gap is measured to identify fuel rod bowing. For the rod gap measurement, the thickness of the top nozzle adapter plate is measured as reference value in the number of pixels by video micrometer, and compared with the as-built data. Repeat the operation from left end to right end.

2.5 Rod Width

Rod width is measured to identify an amount of transversal irradiation growth of a fuel using a linear variable differential transformer(LVDT) based system that measures the distance between two jaws positioned on each side of the measured grid

2.6 Rod Diameter

The continuous axial diameter of peripheral fuel rods in a fuel assembly is measured by linear variable differential transformer(LVDT) which is made up of two fingers between adjacent pairs of spacers.

2.7 Rod Oxide Thickness

Rod Oxide thickness is measured in order to verify oxide and corrosion behavior during operation. Point data for oxide thickness are collected for all fuel rods both on probe insertion and withdrawal.

2.8 Burnup

Dose measurement and evaluation techniques for radiation safety management are important when storing and transporting the spent fuel. In particular, the burnup of nuclear fuel must be considered to ensure the criticality safety during storage and transport of spent fuel [4,5]. The burnup is calculated by PWR 3-D nuclear design code and measured using equipment. As shown in Fig. 2, typical equipment measuring the burnup is ORNL's 'Fork detector system' [6] and CANBERRA's 'SMOPY' [7]. Therefore, we are going to verify the reliability between the calculation and measurement of burnup.

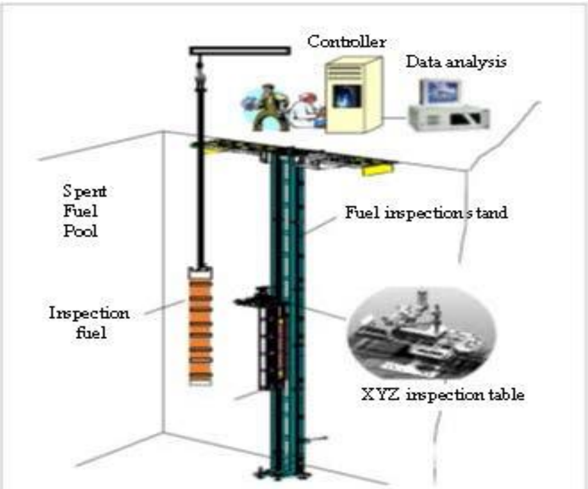

Fig. 1.Schematic diagram of PSE examination

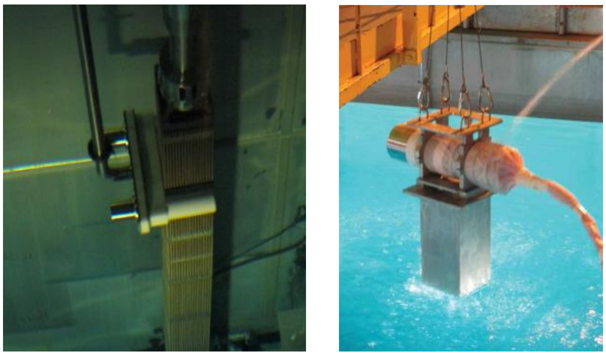

Fig. 2.Burnup measurement devices (fork detector system (left) / SMOPY(right))

3. Target Fuel Selection

At present, it is very difficult to inspect all spent fuel assemblies stored in the spent fuel pool. Therefore, we need to evaluate the characteristics of the spent fuel through the fuel performance analysis code instead of the measurement.

First, the representative spent fuel was selected for verification. There are 14WH, 16WH, 17WH, and 16CE types of fuel assemblies used in the domestic nuclear power plant, and the cladding material of the fuel rods is Zr-4 and Zirlo. We will select the additional fuels considering the items already inspected and the degree of burnup in detail. The time required for the inspection is estimated to be 1 month per 10 assemblies including installation and demolition period.

4. Conclusions

In accordance with the government's 'basic policy on high level radioactive waste management', the spent fuel dry storage in PWR site is being promoted. Under the government policy, the KHNP plans to build and operate a dry storage facility in the plant. In order to efficiently to operate a dry storage facility in a power plant, it is important to characterize the spent fuel. Therefore, KHNP intends to establish a system for inspection and evaluation the characteristics of spent fuel in spent fuel pool by performing PSE. PSE and the establishment of database system should be performed for the standardized spent fuel safety information. Based on the derived safety information, it can satisfactorily meet the requirements for the delivery of KHNP-KORAD, and can be further used as a countermeasure for the demand for the total inspection of spent fuel. This will enable timely responses to licenses to prepare for dry storage in nuclear power plants. Finally, safety can be verified by evaluating the mechanical integrity of spent fuel before it is stored in a dry storage system. This will increase the public acceptance by securing the safety of spent fuel storage in nuclear power plants.

REFERENCES

[1] Notice of the Ministry of Trade, Industry and Energy, No.2016-249, 'Basic Policy on High Level Radioactive Waste Management' (2016)
[2] EPRI, "EPRI Workshop on Poolside Fuel Inspection Technologies and Enhancements, 1011493, 2004
[3] J C Shin, KNFC, "Poolside Examination Techniques Applied for Development of an Advanced PWR Fuel, Plus7^{TM}
[4] Toubon H, Riffard C, Batifol M, Pelletier S, Burnup Credit Applcations for UO2 and MOX Fuel Assemblies in AREVA/COGEMA. International Conference on Nuclear Criticality Safety, 2003.
[5] International Atomic Energy Agency, Implementation of Burnup Credit in Spent Fuel Management System, IAEA TECDOC-1013, 1997.
[6] S. Vaccaro, I.C. Gauld, J.Hu, Advancing the Fork Detector for Quantitative Spent Nuclear Fuel Verification.
[7] CANBERRA, "Fuel Burnup Measurement Services, 2016.