Demonstration Test Program for Long–term Dry Storage of PWR Spent Fuel

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1. Introduction

In Japan, Mutsu interim spent fuel storage facility is preparing for the maximum 50-year storage until reprocessing in dry metal casks for both transportation and storage. The cladding integrity of spent fuel will be maintained during interim storage and safety of post-storage transportation will be ensured based on the knowledge and experience concerning integrity of spent fuel during dry storage in Japan and overseas. The planned interim storage facility has no hot cell to comfirm inside casks before post-storage transportation. So, the Nuclear Safety Commission of Japan (NSC) required utilities to accumulate knowledge and experience on integrity of fuel and casks in dry storage. Therefore, to ensure safety of post-storage transportation, some of Japanese electric companies (The Japan Atomic Power Company, The Kansai Electric Company and Kyushu Electric Company (hereinafter called “the utilities”)) are planning to conduct a long-term storage demonstration test of PWR spent fuel assemblies in the similar environment to actual casks and to confirm the spent fuel integrity, because they have no experience for dry storage of PWR spent fuels in Japan. In this test, the utilities plan to install a compact test container in the research facility (Nuclear Development Corporation (NDC)) which is an affiliated company of Mitsubishi Heavy Industries, and store one or two spent fuel assemblies in it for maximum 60 years. Also, they plan to analyze the internal gas periodically and confirm the fuel cladding integrity. This document introduces the backgrounds, the overall test plan and designing of the test container.

2. Demonstration Test Program

Integrity of 48GWd/t type spent fuel and 55GWd/t type spent fuel will be confirmed in the storage test. Now preparation for a license are underway based on design and safety analyses of the test container. The container will be manufactured in 2011 and storage test of 48GWd/t type fuel will start in fiscal 2012. For the first 10 years, only 48GWd/t type fuel will be loaded, and then 55GWd/t type fuel will be added. The test is planned to continue for maximum 60 years. During the storage test, appropriate test environment in the container (i.e. temperature and atmosphere) and no action of significant external force are confirmed by monitoring temperature, visual appearance of the test container and lid sealing performance. At the same time, the spent fuel integrity is confirmed by conducting internal gas sampling and Kr-85 analyses periodically.

A container body mainly consists of an inner cylinder as a containment boundary, a thick mid-body for gamma-ray shielding and resin for neutron shielding. Basket spacer is composed of boron containing aluminium alloy to maintain subcriticality. The container has a single lid and double metal gaskets. The specification of the test container is determined considering thermal, chemical and radiation condition of actual casks. Fuel temperature in the storage test is approx. 250°C for 48GWd/t fuel and approx. 230°C for 55GWd/t fuel at the beginning of the test. The cavity of the test container is filled with helium gas, whose pressure is extremely lower than that of actual casks due to keeping thermal condition during only 48GWd/t fuel storage. Thermal design of the test container is important. Its temperature is controlled by thermal insulators and heat-transfer performance is confirmed by heat transfer tests at the completion of the container.

The following inspections of fuel integrity are conducted before, at the beginning of, and during the storage test.

(1) Confirmation before storage tests

The spent fuel assembly is confirmed for its integrity before the dry storage test. It is confirmed by observing visual appearance of 4 outermost surfaces of the fuel assembly with an underwater camera.

(2) Confirmation at the beginning of storage tests

At loading of 48GWd/t fuel into the test container and at additional loading of 55GWd/t fuel, the fuel integrity after the loading operation is confirmed. No leak of the fuel rods is ensured by conducting gas sampling and analyses of Kr-85 and compositions.

(3) Confirmation during storage tests

The test condition is confirmed by analyses, gas sampling from inside of a test container and monitoring it from outside during storage until the completion of the test.

For the purpose of detecting fuel rod failure, gas samples inside of the test container are taken periodically using a sampling pod (scheduled every 5 years) to conduct gas analyses. The sampled gas is analyzed for radioactive gas (detection of Kr-85) with a Ge semiconductor detector and components with a mass spectrometer. If any problem like significant increase of Kr-85 level is detected, the test will pause to evaluate effect on safety and investigate the cause.

Monitoring of temperature of the outer surface in the middle area of the test container and the pressure of gap between double metal gaskets, visual inspection of outside of the test container and maintenance of monitoring instruments are performed in proper frequency during the test.

The safety of the test container is verified by the safety analyses on shielding, subcriticality, containment, heat transfer and structure.

3. Summary

- Some Japanese utilities are planning to conduct a long-term storage demonstration test for maximum 60 years for PWR fuel assemblies under the atmosphere simulating temperature and internal gas of actual casks to accumulate knowledge and experience on long-term integrity of PWR spent fuel during dry storage.

- The storage test plan such as test methods and inspection items, container design and safety analyses have been prepared. In the future, licensing and manufacturing of the test container are to be done, and the storage test of 48GWd/t fuel will start at fiscal 2012.

- Thermal design of the test container is important. Its temperature is controlled by thermal insulators and heat-transfer performance is confirmed by heat transfer tests at the completion of the container.

- In addition, Japan Nuclear Energy Safety Organization (JNES) is planning an additional test using the test container from a regulator’s standpoint.