Development of CANDU Spent Fuel Sipping System

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1. Introduction

As the tendency is toward radioactivity zero-leakage on the reactor core for the safe operation of nuclear power plants, the importance of detecting radioactivity leaking from fuel assemblies irradiated in the core is being on the rise. Nuclear fuel, even though it is designed and fabricated in terms of excellent thermal performance and mechanical integrity, can be damaged under unexpected circumstances. An excessive hydriding on fuel rods and pellet-to-clad interaction., etc. can result in failed fuel rod. It is, thus, considered that a inspection process is prerequisite procedure to identify causes of such failed fuel rods for the safe operation of nuclear power plants. If a fuel rod failure occurs during the operation of a nuclear power plant, the coolant water becomes contaminated by leaked fission products, and the power level of the plant has to be lowered or the operation to be stopped. In addition, the spent fuel that have been stored in a spent fuel storage pool for a long time is now transferring to a dry storage. To maximize the integrity of the dry storage, all the fuels transferring to a dry storage should be examined their integrities exactly and efficiently. Therefore, the ultimate purpose of this study is to develop a system capable of judging whether the long-term stored fuel in spent fuel storage pool is failed or not. In this study, a spent fuel sipping system with wet leakage detection technology is developed to make it possible.

2. Development of Sipping System

The methods to inspect nuclear fuel, generally well known, are divided largely into precise visual examination, ultrasonography, and measurement of radioactivity with fission products. This study adopted a sipping system that utilizes the leakage of gases and liquid holding fission products. The overall concept of the system is shown in Figure 1.

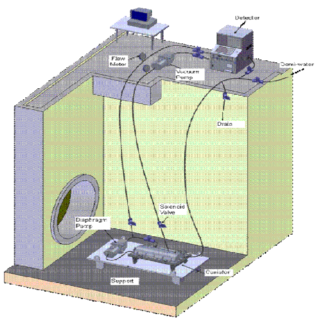

Fig. 1. System Concept

2.1 Equipment Unit

The equipment unit consists of the canister, valve, pump, stand, piping and fittings. The equipment is installed inside the storage pool to prevent the fuel stored in the canister from leaking out to the outside. In designing, stainless steel was selected as its material and the structure allowing CANDU spent fuel's easy loading and discharging was considered. For waterproofing, the canister was sealed with radioactivity-resistant polyurethane. The canister coupled with the valve console was installed on the bottom (boric acid solution present at the bottom) of the pool with the depth of 5m. The canister, as a weldment of a container shape that holds spent fuel, covers up tight it.

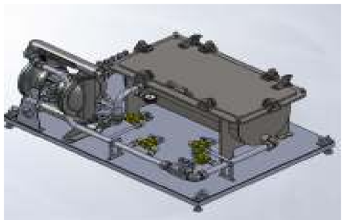

Fig. 2. Equipment Unit

2.2 Control Unit

The control unit consists of PLC-based control equipment (Operating box, Equipment and Control panels), a flowchart-diagram display and so on. The equipment panel, which is a structure of a box shape installed on an operation space outside the storage pool, includes a local power panel electrically controlling pumps and valves, an air service unit supplying compressed air and a valve controlling fluid flow. The operating box is portable as a control panel is installed inside the box case and performs remote control of the entire system. It by communicating with the local power panel of the equipment panel carries out on its touch screen the automatic or manual control.

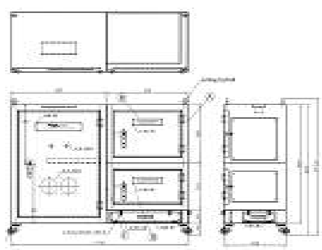

Fig. 3. Control Unit

2.3 Analysis Unit

The analysis unit consists of a radiation detector, multi-channel analyzer (MCA), sample chamber. The NaI (Tl) scintillation detector (3inch×3inch) and other analysis circuits (amplifier, high voltage PS and multichannel analyzer, etc.) were designed together, which are to measure gamma rays from liquid samples. The range of energy to be measured was 50 keV ∽ 3.5 MeV, and the entire H/W for radioactivity detection was designed to be automatically controlled by using programmed S/W. MCA built in a computer convert radioactivity to electric signals, to supply high or low voltage, to amplify and linearize output signals of the detector and to analyze nuclides.

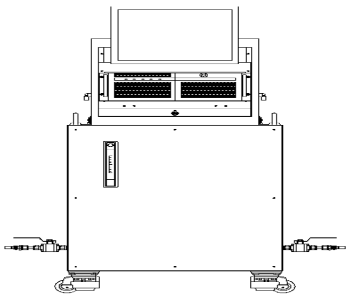

Fig. 4. Analysis Unit

3. System Performance

The sipping system is portable and was loaded into the Wolsong-1 fuel bay on Mar 24. 2009 for the system performance test. On Mar 25 and 26, the five spent bundles were subjected to sipping tests. It produces 3 basic gamma activity measurements, referred to as "BKG", "Liquid Gross", and "Gas Gross". The sipping system employing a sodium iodide detector showed good results.

4. Conclusions

The objective of this study is to develop the spent fuel sipping system that is able to distinguish the failed fuel bundles from many of the isolated fuel bundles due to the possibility of failures. The performance test in Wolsong-1 plant proved that the sipping system could effectively determine whether or not irradiated fuel bundles are defective. There is no doubt that the sipping system will increase the safety of the nuclear power plant by reducing the possibility of fuel failures. With the complete fabrication and service technology in the field of heavy-water reactor, proper preventive measures and methods to identify causes of failures can be obtained, therefore resulting in supplying of excellent quality fuel with zero-defect. It is an essential element to develop the advanced fuel technology competitive over the world that the feedbacks from in-core performance of fuel to designing and manufacturing technology and accordingly, to form the foundation for a rising export in the relevant fields.

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