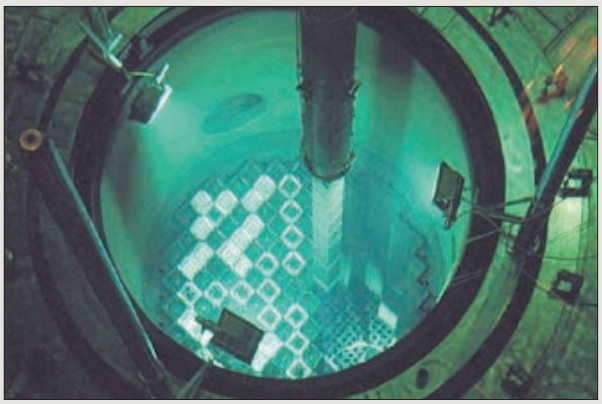
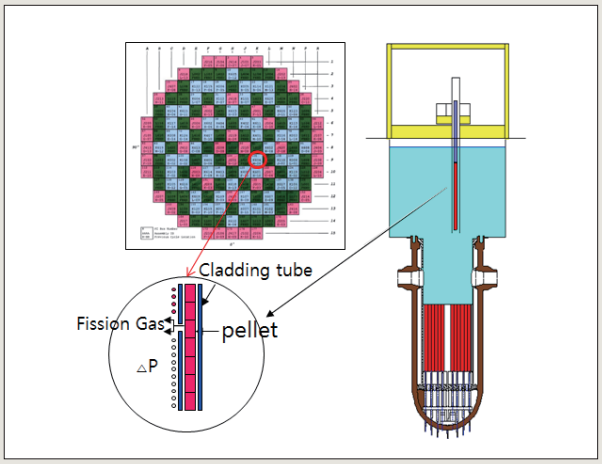
IMS(In Mast Sipping) Technology for Damaged Fuel Detection

KNF–SF–03

Overview

IMS (In Mast Sipping) is a technology to detect the leakage defect by collecting and analyzing fission gas that leak out from inside of the fuel in the event of defect in spent fuel such as pinhole. When the fuel is unloaded from the reactor, a water pressure difference of 15 psig is generated by a vertical lift of about 10 m, and this pressure drop causes the fission gas inside of the fuel rod to leak out of the fuel rod. Fission gas has a variety of nuclide such as Xe-133 and Kr-85 and it is possible to detect and analyze these nuclides by IMS technology.





Description

Background

Domestic nuclear power plants have relied on VT (Visual Testing) and UT (Ultrasonic Testing) to detect the leakage defects in spent fuel in the past. Since VT and UT must be carried out separately after the fuel is withdrawn, delay of detection of leaking fuel is unavoidable. Moreover, it is difficult to read leakage defects inside the fuel with VT, and in case of UT, it is not possible to detect a leakage defect if there is no water inside the leaking fuel rod. Accordingly, KEPCO NF developed IMS equipment that can perform reliable test.

Purpose and Necessity

Since IMS is performed simultaneously with fuel unload from the core, there is no additional fuel transfer for the inspection. Minimizing the transfer of fuel has the advantage of reducing fuel damage factors. Fuel that has determined to have leakage defects can be repaired and reloaded into core or safely stored in the spent fuel pool. In addition, inspection results can be reflected in redesign of the core.

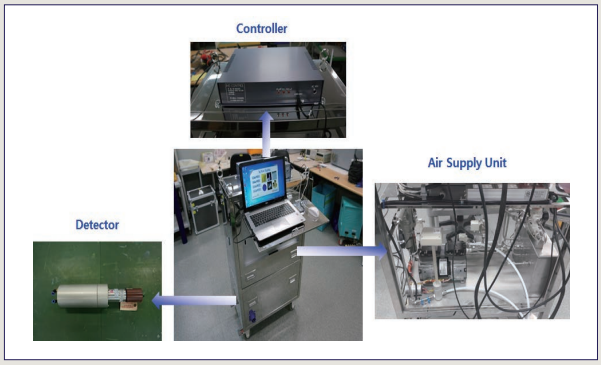
IMS can detect leaking fuel even if there is no water inside the fuel rod unlike UT. In addition, since IMS is completed in fuel withdrawal process, it is possible to select the leaking fuel as a group prior to UT. The selected set of leaking fuel assemblies are then subjected for intense examination in UT to detect the leaking fuel rods. This process can improve the probability of detecting leaking fuel rather than the method of performing UT itself.

System Configuration

- **IMS Equipment**

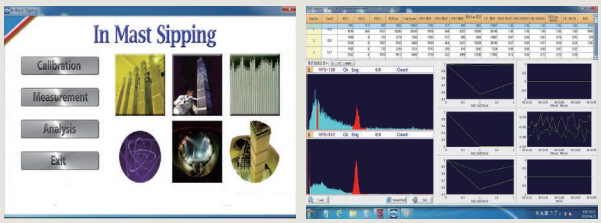
  The control system controls devices such as MCA (Multi Channel Analyzer), vacuum pump, solenoid valve, humidity

sensor, pressure sensor, flow sensor, and it consist of a DAQ (Data Acquisition Board) which acquires signals and data, digital system which simultaneously controls air supply devices and detection analysis device, and laptop for processing acquired signals and for display and database purposes. The air supply system inhales the fission gas inside the mast, sends it to the detection analysis device, and discharges the gas back into the atmosphere. It consist of vacuum pump, valve, air dryer, regulator, gauge, air transfer tube and various sensors and connectors. The detection analysis system analyzes the fission gas inhaled from the mast to determine whether the fuel is detective or not. It consist of detector, MCA, lead shield, and laptop.



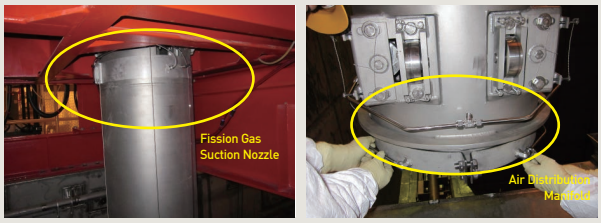
- **IMS Program**

  All devices installed on IMS device can be controlled by IMS program. And the program provides the function of calibration, leaking fuel inspection and analysis. Using 1,024 channels of MCA, it is possible to analyze various nuclide in the range of radioactive energy from 10 ~ 1,000 keV. Through this program, it is possible to check not only the radiation measurement value of the detector but also the pressure and flow of the inhale line in real time.



- **Mast Fixing Device**

  Mast fixing device is an auxiliary device installed on the external mast of the reactor for IMS, consisting of suction nozzle installed on the upper part of the mast and an air distribution manifold installed on the lower part of the mast. The suction nozzle is connected to the detector of the IMS device by an air hose and the vacuum pump starts to inhale the fission gas when the inspection is started.
  The air distribution manifold is connected to the service air line of the power plant. From the beginning of the inspection, service air is injected into the bottom of the fuel assembly to activate the collection of leaking gas.



Distinctiveness

Characteristics

- Fuel damage is reduced by minimizing transfer of spent fuel for fuel inspection.
- Various nuclide in the range of radioactive energy from 10 ~ 1,000 keV can be analyzed by using 1,024 channels of MCA
- Identification of leaking fuels in real time with fuel inspection
- Improved resolution by blocking noise from natural radiation and electromagnetic waves
- Increased reliability of leaking fuel detection by simultaneous analysis of gamma and beta nuclide

Benefits

- Utilization of leaking fuel detection for BNPP
- Ensure customer reliability with prompt and accurate service when leaking fuel is found
- Enhanced probability of leaking fuel detection by complementing different physical properties with UT

Experience

- 6 times IMS inspection for domestic pressurized water reactor

Deliverables

- Design and manufacture of IMS equipment
- IMS service performance for power plant
- IMS training and manual

*** Technology Readiness Level (TRL)**
: Actual system proven through operation
*** Business Model**
: Service Execution

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