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Development of an Ion Chamber for Monitoring the Containment of a Nuclear Power Plant

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1. Introduction

Nuclear power plants need many different types of radiation detectors for different purposes. Neutron detectors are installed inside and outside of the core to check the neutron flux. Scintillation detectors are used to check the fission products included in the liquids and gases of plant system. Geiger-Mueller counters are used for the area radiation monitoring.

In addition to the above-mentioned detectors, ion chambers are installed to monitor radiation level of the containment. A few ion chambers are located within the reactor containment to monitor radiation level of an accident case. Therefore, the ion chamber should be capable of monitoring high level radiation dose up to 10^7 R/h. Korea Atomic Energy Research Institute (KAERI) developed an ion chamber for monitoring the radiation dose inside the containment.

2. Methods and Results

In this section, the design and fabrication characteristics are described. Am-241 gamma sources were used to test the ion chamber. The test results are also described.

2.1 Ion Chamber Specifications

An ion chamber consists of an anode (collecting electrode), a cathode and a filled gas in general. A cathode usually has a cylindrical shape and is made of a steel or carbon-coated polyethylene [1]. The anode is usually located at the center of the cathode cylinder and has a rod shape. The length and diameter of the anodes were decided based on the electrical field applied inside the detectors. Air is used as a filled-gas in general. If a higher sensitivity is required for an ion chamber, the pressure of the filled gas should be increased or the gas type be changed to Ar or Xe.

The ion chamber developed for the containment monitor is supposed to check the high radiation level in case of a reactor accident. Therefore, a normal type of an anode and cathode system may not be adequate due to the high ionization current inside the ion chamber. If too much ionization happens, ionized gas and electrons may be recombined before they are recorded as signals. The ion chamber for the containment monitor was developed to have 31 flat disks stacked on 6 disk rods. Sixteen anode (collecting) disks and fifteen cathode (signal) disks are interleaved to collect ionized gas and electrons effectively.

The electrodes assembly is installed inside a housing made of SUS304. The housing has a cylindrical shape with the diameter of 165 mm. The mounting flange is also made of SUS304 with the diameter of 210 mm. The height of the housing is 203 mm from the bottom to the mounting flange. The flange and housing was sealed through screws.

Two pin connectors are installed through the flange. One is BNC connector for the signal and the other is SHV connector for the collecting electrodes. A quick connector is located at the center of the flange for exhausting and back-filling of the ion chamber. The filled-gas is 1 atm air. Since the quick connector is used for a gas filling system, the type of gas can be changed easily at any time.

2.2 Leakage Current

After the fabrication of the ion chamber was finished, vacuum test was performed to check the status of sealing. After the sealing was checked, the leakage current was measured. An ORTEC 556 high voltage power supply was used to put +500 V on the collecting electrodes. Keithley 6517A electrometer was used to measure the leakage current.

The leakage current was measured for about 2 hours and did not show much fluctuation. Fig. 1 shows the results of measurement performed for 30 minutes. The average was 0.75 pA which is greater than other ion chambers developed by KAERI [2]. Since the containment detector is supposed to monitor high radiation dose, the leakage current of 0.75 pA is acceptable. The containment monitor is supposed to monitor the radiation range of 1- 10^7 R/h. It is expected that the current level is about 100 pA when the radiation level is 1 R/h. The leakage current 0.75 pA is acceptable compared to the minimum signal current of 100 pA.

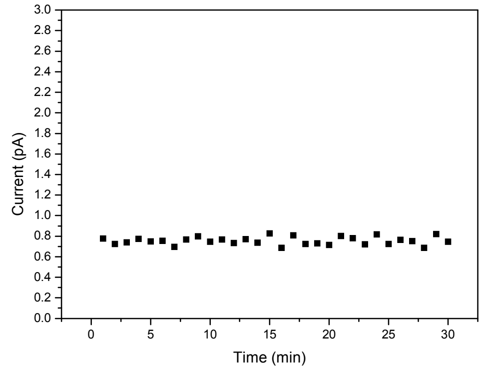

Fig. 1. Leakage current of the ion chamber

2.3 Gamma Source Test

After the leakage current was measured, we measured the signal current due to a gamma radiation. Am-241 gamma source was used for that purpose. One Am-241 source was 25 mCi and we used two such Am-241 sources. The windows of two Am-241 sources were contacted with the bottom surface of the ion chamber. Fig. 2 shows the current measured for 30 minutes. The average value was 1.66 pA which was increased by 0.91 pA compared to the leakage current. Therefore, 0.91 pA is the current corresponding to the Am-241 gamma radiation.

It is required to calibrate the ion chamber for using the detector in the real nuclear power plant. The calibration work is under progress. After the calibration work is finished, QA work will be followed to install the ion chamber in the nuclear power plants.

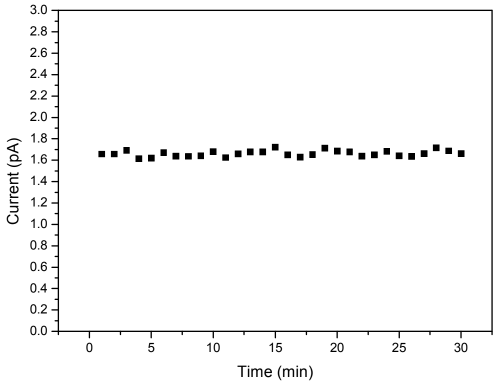

Fig. 2. Current measured by irradiation of two 25mCi Am-241 gamma sources.

3. Conclusions

Ion chambers are located within the reactor containment to monitor radiation level of an reactor accident cases. Therefore, the ion chamber should be capable of monitoring high level radiation dose up to 10^7 R/h. Korea Atomic Energy Research Institute (KAERI) developed an ion chamber for monitoring the radiation dose inside the containment.

The ion chamber for the containment monitor was developed to have 31 flat disks stacked on 6 disk rods. Sixteen anode (collecting) disks and fifteen cathode (signal) disks are interleaved to collect ionized gas and electrons effectively.

After the fabrication of the ion chamber was finished, the leakage current was measured. . The leakage current 0.75 pA is acceptable compared to the minimum signal current of 100 pA. The signal was measured by using two 25 mCi Am-241 gamma sources. The calibration work is under progress. After the calibration work is finished, QA work will be followed to install the ion chamber in the nuclear power plants.

REFERENCES

[1] Y. K. Kim et al., “Development of Radiation Detector Technology,” KAERI Research Report, KAERI/RR-2538/2004, 2005.

[2] H. S. KIM et al., “Characteristics of Nobel Gas-filled Ionization Chambers for a Low Dose Rate Monitoring,” Proceedings of 2007 Spring Korean Nuclear Society Meeting, 2007.