Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Introduction of Newly Installed DNAA System at HANARO

Jongguk Kim,a Il-Jin Park,a Gilhoon Ahn,a Gyungsik Min,a Sunha Kim,b Yongsam Chung,b
a Korea Institute of Nuclear Nonproliferation and Control, Daejeon, Rep. of Korea
b Korea Atomic Energy Research Institute, Daejeon, Rep. of Korea

1. Introduction

The advantages of Neutron Activation Analysis coupled with delayed neutron counting (DNAA) have contributed to nuclear nonproliferation and other nondestructive analysis. Detection and quantification of traces of fissile material is accurate and fast, and preparation of samples is convenient due to needs of small amount with various types of complex matrices such as soil, vegetation, plastic, rock, cloth, and water nondestructively. Especially, analysis of hot cell swipes as a screening method is of utmost efficient in both low cost and rapid analysis. Fissile materials such as ^{239}Pu and ^{235}U can be made to undergo fission in the intense neutron field. Some of the fission products emit neutrons referred to as "delayed neutrons" because they are emitted after a brief decay period following irradiation. Counting those delayed neutrons provides a simple method for determining the total fissile content in the sample [1].

The Installation of DNAA system has started at High-flux Advanced Neutron Application Reactor (HANARO) since the fluence rate in HANARO (3×10^{13} n·cm^{-2}·s^{-1}) is relatively enough [1] to yield of a detection limit of 15×10^{-12} grams per gram (g/g) for ^{235}U [2]. In last year, our developed DNAA system was successfully installed, and recently new pneumatic transfer tube system (PTS) was completed for the test. This presented paper introduces a test-run result and future work is discussed.

2. Methods and Results

2.1 Description of Newly Installed DNAA System

The delayed neutron facility in High-flux Advanced Neutron Application Reactor (HANARO) consists of the pneumatic transfer tube, pneumatic tube programmable logic controller and user interface, neutron detector assembly and signal processing equipment. Figure 1 shows a schematic of the delayed neutron activation analysis (DNAA) counting system. Eighteen He-3 proportional counters are spaced in two concentric rings around the flight tube. Each counter measures 2 inches in diameter and has an active length of 13 inches. Polyethylene moderator surrounds the detectors and flight tube and forms a cube approximately 18 inches in each dimension. Two inches of lead shielding are molded around the flight tube and air exit line at the counting position. The polyethylene moderator is topped with a half-inch aluminum plate and surrounded with four inches of borated polyethylene neutron shield and one inches of lead.

The detectors are grouped in three groups of six, and the aggregate signal of each group is amplified and converted to digital signal. Bias is typically +1000 to +1600 V and is applied to all six detectors in a group through a manifold which contains a capacitor for smoothing. Ultimately, total counts for each detector group are obtained from a 3-channel scalar that also controls counting time.

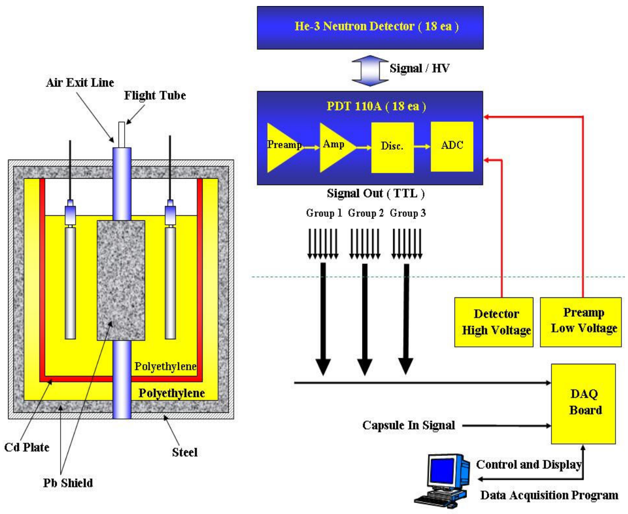

Figure 1. A Schematic of the DNAA Counting System.

The rabbits, polyethylene sample containers, are loaded into the pneumatic tube in a fume hood loading station, irradiated for pre-selected time, and automatically moved to the delayed neutron counting assembly.

Figure 2. Picture of newly installed DNAA Counting System ; Shows (1)DNAA Counting System on left, (2)Sample loading station on middle, and PTS on right.

[1] The fluence rate of 4×10^{13} n·cm^{-2}·s^{-1} is adequate to yield a detection limit of 15×10^{-12} grams per gram (g/g) for ^{235}U.

The sample containers move by means of counter-current air columns which transfer the rabbit from the loading station to the reactor and from the reactor to the counting room in about 5 seconds. The maximum sample size is a right cylinder of a diameter of 10 mm and height 60 mm. The thermal neutron fluence rate in HANARO is $\sim 3\times10^{13}$ n·cm^{-2}·s^{-1}.

2.2 Detector Calibration Using Neutron Source

The efficiency of the He-3 detector was determined by using Am/Li source. This type of source was selected because its energy spectrum is similar to that of delayed neutrons [3]. Since He-3 is more sensitive, electronically stable, but is affected more by gamma-ray interactions and may require a higher low-level discriminator setting for operation, threshold on preamplifier has been adjusted to be optimized for the expected gamma-ray background generated by the sample, desired detection limits, and electronic stability of the counting system. As seen in figure 3, the count rate was measured with respect to the applied high voltage using Am/Li neutron source (2.9 mCi). From the plotted slope, proportional region between 1150 V and 1350V has been determined as operational voltages.

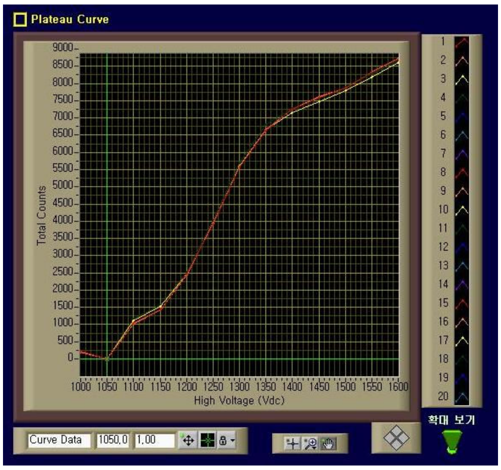

Figure 3. Measured count rates as a function of applied voltages on Helium-3 Detectors.

3. Conclusion

DNAA is an excellent screening method for wide area monitoring, protection of clean room facilities, and for routine surveillance of facilities. This method accommodates 50-100 samples each day that the HFIR operates and has very low cost compared to mass spectrometric methods [4]. We have collaborated with Oak Ridge National Laboratory to strengthen environmental sampling analysis and DNAA method since 2002 under the PCG (Permanent Coordinating Group) safeguards arrangement between the United States Department of Energy (DOE) and the Ministry of Science and Technology of the Republic of Korea (MOST). Finally, Successful Installation of DNAA System at HANAO is followed by active feasibility study and design discussion on pneumatic tube and delayed neutron counting system.

This year, we are planning to run DNAA system at HANARO for the comparison of previous sample results by HFIR.

REFERENCES

[1] F. F. Dyer et al., “A comprehensive study of the neutron activation analysis of uranium by delayed neutron counting,” ORNL-3342 (1962).
[2] T. M. Sims and J. H. Swanks, “High Flux Isotope Reactor Experiment Facilities and Capabilities,” ORNL (1979).
[3] S. Synetos, and J. Williams, “ Delayed Neutron Yield and Decay Constants for Thermal Neutron Induced Fission of U-235,” Nuclear Energy 22, 267 (1983).
[4] F. F. Dyer et al., “Design and use of the ORNL HFIR pneumatic tube irradiation systems” Journal of Trace and Microprobe Techniques, Vol. 6 (2), 147-159 (1988).