The KINAC Capabilities to Support Environmental Sampling for Safeguards

Gil Hoon Ahn*, Jong-ho Yoon, Hnna Seo, Ki-tek Han, Jung Youn Choi
Korea Institute of Nuclear nonproliferation And Control
1534 Yuseong-daero, Yuseong-gu, Dadjeon, 305-348
**Corresponding author: ahn@kinac.re.kr*

1. Introduction

Environmental sampling is one of the most powerful safeguards means that contribute to confirming the absence of undeclared nuclear material or nuclear activities[1]. The KINAC, in collaboration with the KAERI and the ITU(Germany), has established an independent environmental sampling program to prepare 'complete verification' discussed in the process of DPRK nuclear issues.

The KINAC has to play a central role in the entire environmental sampling programme, in particular, to prepare certified ultra-pure sampling kits and quality control(QC) samples, to collect, screen and split swipe samples and distribute sub-samples with QC samples to the KAERI and the ITU without significant risk of cross-contamination and to perform detailed evaluation as a part of the laboratory's activities.

Samples are analyzed in either bulk or particle mode. Bulk analysis is performed by the KAERI and means the analysis of an entire sample where the analytical measurements represent average results for the material contained in the sample. Particle analysis is performed by the ITU and involves the detection and analysis of individual particles in the micrometer size range and on the measurement of the isotope ratios of uranium in them.

This paper will describe the status and future goals of the KINAC in the field of environmental sampling for safeguards(ESS).

2. Methods and Results

2.1 Sampling kits

One of the main activities of the KINAC is the preparation of clean sampling kits for collecting environmental samples. A kit for the collection of swipe samples is shown in Fig. 1. The standardized cotton swipe kit is pre-labeled with an identification number and contains eight cotton swipes individually packed in small mini-grip bags. A kit also includes medium mini-grip bags for double bagging, labels, paper seals, two pairs of clean-room gloves, a pen, and a sample collection sheet with sampling instructions. A roll of aluminium foil is provided to set a clean working surface.

Fig. 1. Swipe sampling kit

2.2 Quality Control of cotton swipe

The purpose of the analysis of environmental samples is to identify and characterize the nuclear material collected on the swipe. A typical list of nuclear materials to be measured includes U, Pu and gamma emitters. The quantities of nuclear materials expected on swipes are shown table 1[2].

Table 1.Expected Characteristics of Nuclear Materials on Environmental Swipes

	Range
Blank level of U	0.1 to 5 ng/swipe(NU)
Blank level of Pu	≤10 fg/swipe
Blank level of fission/activation products	≤1 mBq/swipe

The KINAC has been used the delayed neutron activation analysis(DNAA) system to support QC activities for measuring blank level of U and Pu in swipes. This system made up of pneumatic transport system(PTS), neutron detector assembly(DNC), and signal processing equipment was installed in HANARO. This research reactor at KAERI has 30 MW maximum thermal power and sufficient neutron flux to detect less than one nanogram of the total fissile content. The DNAA system shows excellent linearity from 0.67 ng to 713 ng ^{235}U, and reproducibility of 1.26% standard deviation for the various mass groups of ^{235}U samples[3].

Fig. 2. DNC(left) and PTS(right)

2.3 Screening Techniques

Collected swipe samples undergo screening in the lab to guide further detailed analysis, and to assist in the shipment of samples to the KAERI or ITU. The Compton Suppression Spectormeter(CSS) was installed to identify radionuclides in swipes and to estimate their activity. The CSS is designed to reduce the background by means of passive and active shielding. The central detector of the CSS is an n-type coaxial HPGe detector with 60% relative efficiency. Its energy resolution at 1.33MeV is 2.3keV. The HPGe detector is surrounded by a guard NaI(Tl) detector for active shielding that is implemented to suppress Compton photon scattered events in the HPGe detector. It consists of an annulus, plug and back-catcher detector. A peak-to-compton ratio(P/C) used as performance criteria evaluated from the measured ^{137}Cs source spectra is 915.1. The measured parameter is better than those reported in the literature[4].

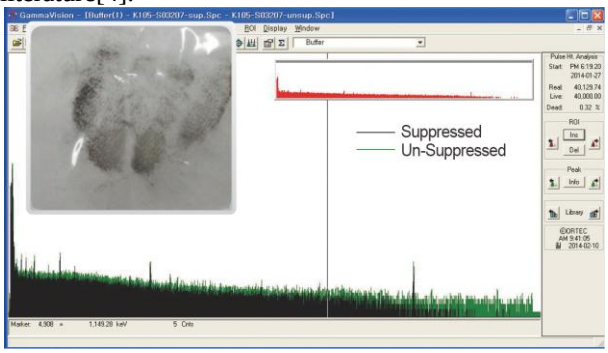

Fig. 3. Output of the CSS

In addition to the gamma screening, XRF screening is performed on all swipe samples to detect uranium. The nuclear material detection limits in commercial gamma spectrometric or XRF analysis typically do not exceed tens of micro-gram. To improve this limitation, the KINAC developed Monochromatic Micro-focusing X-Ray fluorescence (MMXRF) which is focused on uranium detection. The MMXRF is facilitated by doubly curved crystal optics(DCC), which direct an intense micron-sized monochromatic X-Ray beam. The X-ray excitation system consists of a 25W X-ray target transmission tube with Ag anode. The SDD detector is used to evaluate the uranium content. The total measurement time for one swipe is about 2.5 hours(1600 positions times 5seconds/position). The uranium detection limit is 16ng/cm^2 of the swipe surface with 100s measurement time[5].

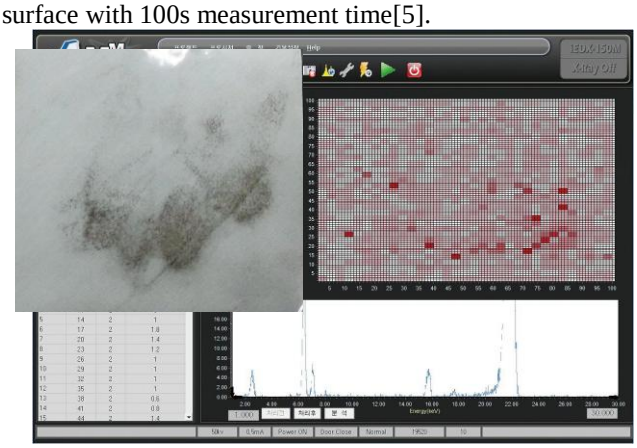

Fig. 4. Output of the MMXRF

2.4 Future Challenges

The KINAC is responsible for the conclusions drawn from the analytical results provided by the KAERI and the ITU. To assure the KINAC of the continuity of the quality of the analytical results provided by the laboratories, the KINAC will implement a QC programme. The QC programme will be based on the periodic analysis of QC swipes performed by individual laboratories. The QC swipes will be submitted to a laboratory in a blind fashion. There are two types of QC swipes. One is a blank swipe and the other is a control swipe. The objective of blank swipe is to check the detection limits of the analysis performed by the laboratories as well as possible contamination and cross-contamination during the analysis(false positive results). The objective of control swipe is to check the analytical accuracy and detection capability of the laboratories (false negative results)[2].

3. Conclusions

Capabilities of the KINAC for ESS have been developed by employment of radiation measurement techniques since 2010. Most of the results of screening system have met the requirements. For further improvement, the KINAC's challenges with emphasis on QC programme appear to be highly desirable.

REFERENCES

[1] International Nuclear Verification series No. 1(Rev.2), Safeguards Techniques and Equipment : 2011 Edition, IAEA, 2011.
[2] STR-343-R, Quality Control Programme for the Analysis of Environmental Samples, IAEA, 2004.
[3] G.H. Ahn, I. Park, J.G. Kim, G. Min, S. Kim, and Y. Chung, Development of the DNAA System for Screening Environmental Samples to Measure fissile material, Journal of Nuclear Science and Technology, Vol. 45:sup5, pp. 654-657, 2008

[4] H. Seo, and G.H. Ahn, Performance test of the Compton Suppression System(CSS), Transactions of the Korean Nuclear Society Fall Meeting, Mct. 25-26, 2012, Gyeongju.
[5] K. Han, J. Yoon, H. Seo, and G.H. Ahn, Performance Evaluation of MMXRF for Screening Environmental Swipe Samples, Transactions of the Korean Nuclear Society Spring Meeting, May 29-30, 2014, Jeju.