Development of NORM determination Algorithm for Radiation Portal Monitors

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1. Introduction

Inspection of a cargo on the airport and harbor has been reinforced all over the world since 9/11 terrorism, particularly in the United States. US coast guard (USCG) suggested the methods for which terrorism could be prevented to international maritime organization (IMO) and the bill in which container safety was assured was suggested by U.S customs officials.

However, radiation portal monitors (RPMs) running at the airport and the harbor cannot distinguish special cargo material (SNM) from naturally occurring radioactive materials (NOMR) containing a small dose of radioisotope from nature. Consequently, cargo sorted out by RPM using polyvinyl-toluene (PVT) scintillator contains approximately 99% of NORM (such as cat litter, potash, tableware and etc.)

Many research institutes are under way to reduce such a nuisance alarm. Tom Burr conducted pattern recognition methods with extracted 184 features (46 features from each of four panels) from 235 profiles out of 406 profiles representing gamma alarm [1]. But this method is more like statistical analysis using the data of low and high gamma than practical nuclide analysis. So it has limitation to reduce nuisance alarm.

In this paper, probability of distinguishing nuclide analysis is proposed by measuring compton energy spectrum of gamma ray with large-area PVT scintillator to solve fundamental problem.

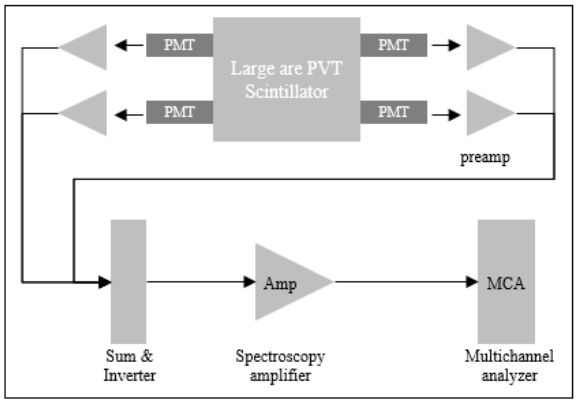
2. Methods and Results

2.1 Energy Spectrum Measurement

In this paper, the experiment to identify nuclide for RPMs was performed to reduce nuisance alarm. To distinguish radionuclide for PVT scintillator, the relationship between the number of emitted photons from scintillator and the energy of the gamma ray should be linear. Therefor energy spectra of general calibration gamma sources were measured using large-area PVT scintillator being developed by the Korea atomic energy research institute (KAERI).

PVT scintillator (1800 x 720 x 50mm, Ej200, Eijen) has four PMTs (Hamamatsu) in which two PMTs are coupled with both sides of scintillator respectively. Each signal from PMT was amplified by customized preamplifier and transferred to summing and inverter (ORTEC) in which four signals were merged into one signal. The merged signal was amplified and shaped in spectroscopy amplifier (794, ORTEC) to be transferred to multichannel analyzer (MCA8000D, AMPTEK). Finally amplified signal was measured in each corresponding channel of MCA. Figure 1 shows the schematic of the experiment setup.

Figure 1 Schematic of the experiment setup



General calibration gamma sources, Cs-137, Co-60, Ba-133, Na-22 and Mn-54 from Table 1, were used to measure various gamma energy spectrum.

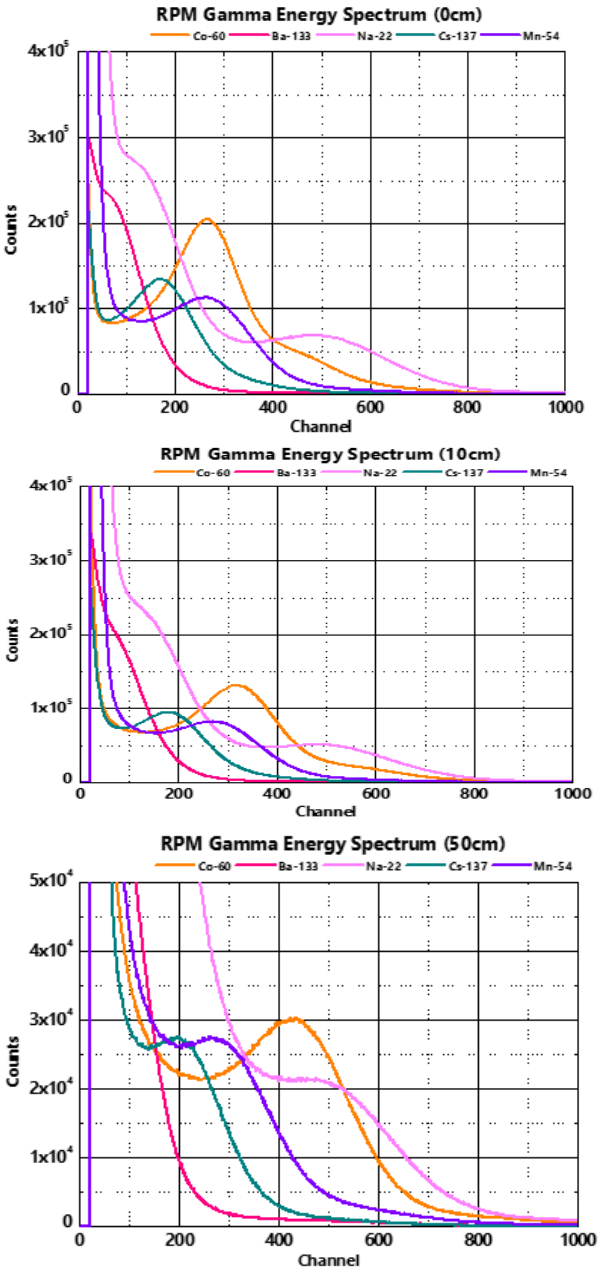
Table.1 Gamma energy spectrum of general calibration gamma sources

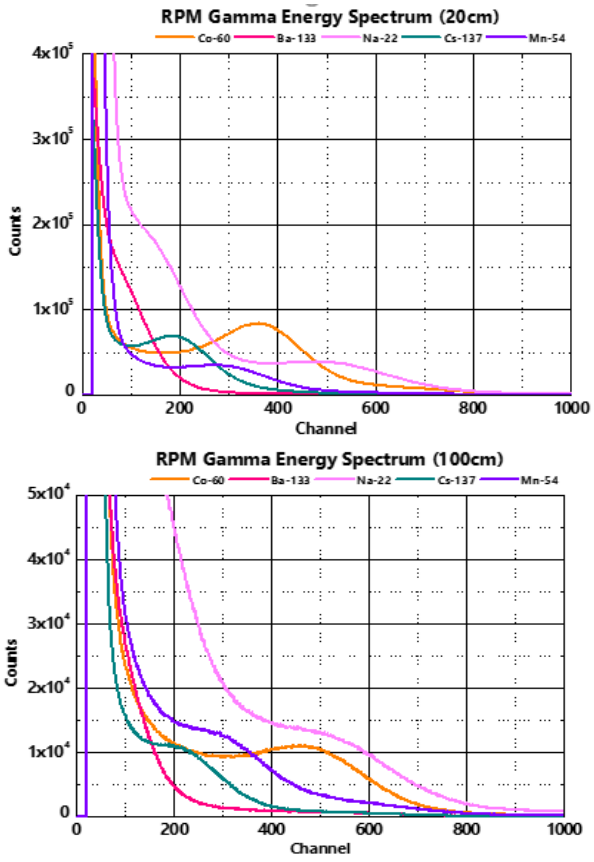
RI	Current Activity (kBq)	Ratio	Energy 1 (keV)	Energy 2 (keV)
Ba-133	1,592	0.94	302.90	356.00
Na-22	132	0.08	511.00	1,274.00
Cs-137	1,686	1.00	662.00	0
Mn-54	426	0.25	834.85	0
Co-60	825	0.49	1,170.00	1,330.00

Gamma energy spectra of five sources mentioned above were measured according to the distance between the scintillator and the radiation source from 0cm to 100cm (0, 10, 20, 50, 100cm). The integration time was 60s based on Cs-137 (1,686 kBq) source considering activity variation by other sources decay.

Figure 2 shows gamma energy spectrum for each source depending on the distance between the source and the detector. The energy spectrum was shifted from low channel to high channel of MCA when the distance was increased from 0cm to 20cm. There was no more channel shifting when the distance was more than 50cm.

Figure 2 Gamma energy spectra of five general calibration gamma sources according to the distance between the scintillator and the source.

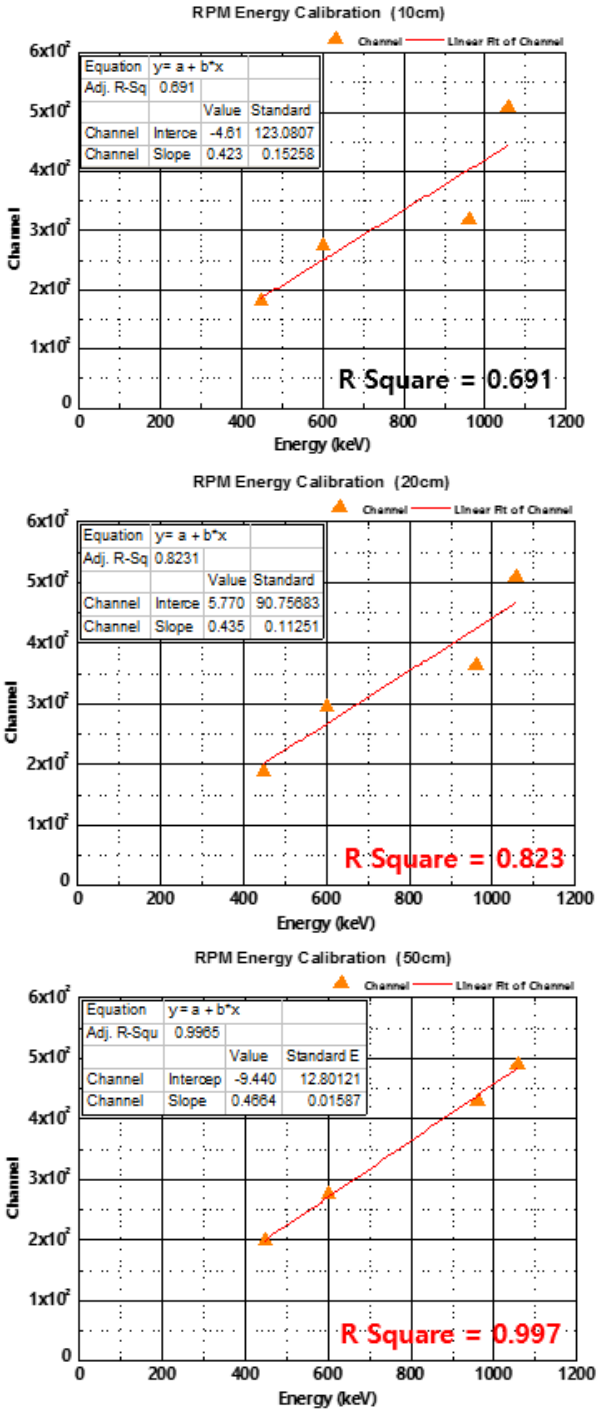


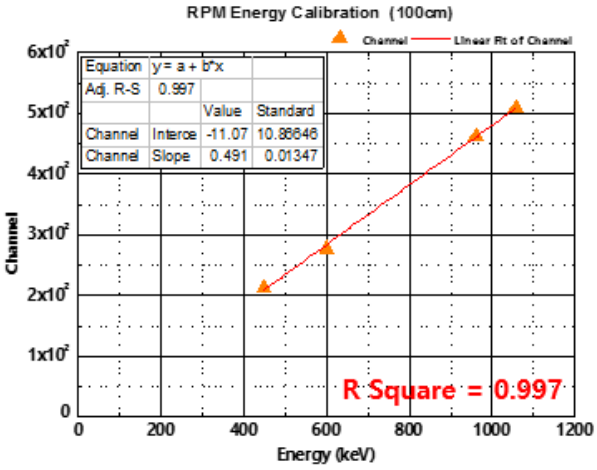


Compton edge values were extracted by Gaussian fitting of Compton spectra of five sources.

Obtained Compton edge values and the channel values were fitted by linear fitting for the energy calibration. Figure 3 shows the linear fitting of Compton edge values of energy spectra according to the distance between the source and the scintillator. R-square values were 0.204, 0.691 and 0.823 for 0cm, 10cm and 30cm respectively. While R-square values were 0.997 for both 50cm and 100cm, which means that it is almost linear when the distance is more than 50cm.

Figure 3 Linear fitting graph of gamma energy spectra according to sources location from scintillator





3. Conclusions

Regarding to the experimental result for difference distances between the source and the scintillator using large-area PVT based plastic scintillator, the linearity was not secured when the distance is from 0cm to 20cm. It is expected that, for these cases, the scintillation areas in which photon is emitted were small. The distance between PMTs and these areas was too far to detect every emitted photon because the photons were attenuated by plastic scintillator. Because of this reason, energy spectra were shifted to relatively lower channel. While, no more spectrum shifting occurred for 50cm and 100cm. It is considered that the increase of the gamma source solid angle makes scintillation area larger and no more spectrum shifting occur.

With this experiment, it was confirmed that close distance between the source and the large-area PVT scintillator below 50cm makes linearity of the spectrum measurement system lower. RPM in operation based on PVT scintillator at the airports or harbors could be secure energy spectrum linearity because container is examined more than 50cm away from RPM.

We expect following study that identifying nuclides to reduce nuisance alarm and detect SNM would be developed with the result from this paper.

REFERENCES

[1] Tom Burr, Signatures for several types of naturally occurring radioactive materials, 2008.