Measurement of Detector Efficiency for the CZT Monitoring System

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1. Introduction

Most exposure of workers at PWRs is caused by CRUD(Chalk River Unidentified Deposits) in RCS(Reactor Coolant System) during the outage. Therefore, we have to know that what a nuclide how much is existed in primary reactor system for reduction of exposure.

This study tried to measure source terms in primary reactor system by using CZT semiconductor device. Evaluation method of using CZT have been being attempted in various places such as AEP(American Electronic Power) [3] etc since EDF(Electricite de France) had apply to the project named "Source Term Reduction" [1][2], [4]-[7]. CZT can measure source terms on various places in nuclear power plants because it is available at room temperature unless a seperate device and portability is good. Consequently, CZT show good result from analysis of source terms in nuclear power plants.

This study found out efficiency of CZT detector that is now researched in CZT Monitoring System for measure source terms on RCS system of domestic old and new nuclear power plants and verified measured efficiency values by comparing to reference efficiency we already know.

2. Methods and Results

2.1 Methods

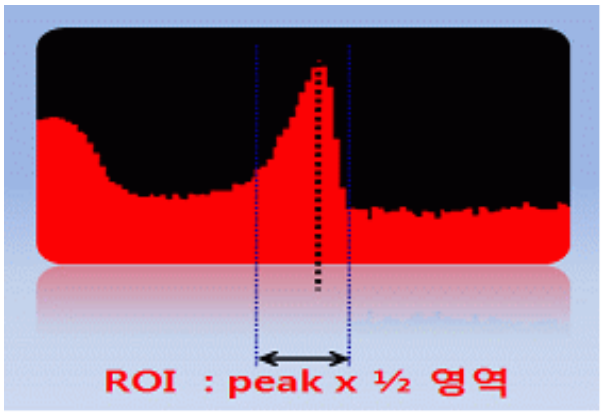

Figure 1 Setting method of ROI

Measurement is carried out by using CZT 1500 and CZT 500 of Ritec(Riga, Latvia) and MCA 527L multi analyzer of GBS Electronik GmbH(Radeberg, Germany). In order to fine out measurement efficiency on each detector, the fist is to fine out efficiency depending on each energy of mixed CRM such as ^{137}Cs(169.4 *nCi*±20%, 662keV) and ^{60}Co(78.1 *nCi*±20%, 1173keV, 1337 keV). And based on this, we found out efficiency from each energy of source terms we don`t have by applying to $\varepsilon(E)=e^{-aE+b}$ function. Detection efficiency is carried out about CZT 1500 and CZT 500. And CZT 1500 measured CRM by various Fine Gain values. Verification was carried out by comparing to reference value of single CRM such as ^{137}Cs(976.9 *nCi*±20%, 662keV), ^{60}Co(876.2*nCi*±20%, 1173keV, 1332keV) and ^{54}Mn(441.8*nCi*±20%, 835 keV).

구분	Parameter set (Fine gain)	channel 수	측정시간(s)
CZT 1500	1	2048	1500
	2.5	2048	4000
CZT 500	2.5	2048	4000

Table 1 Measurement condition depending on detectors

Detection values of CRM defines as sum of counts per channel in the scope that set up left and right ROI scope as the central value 1/2 on energy peak point of nuclides as the figure 1. Measurement conditions equate to table 1.

2.2 Results

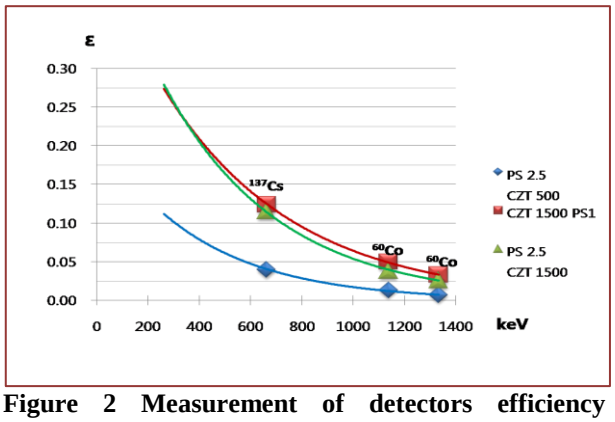

Figure 2 Measurement of detectors efficiency depending on energy

Figure2 showed detection efficiency of detectors from each energy by using ^{137}Cs(169.4 *nCi*±20%, 662keV) and ^{60}Co(78.1 *nCi*±20%, 1173keV, 1337 keV) . As we expected, detection efficiency of all of detectors showed a clear decrease depending on increasing energy of

구분		Cs-137 (nCi)			Mn-54 (nCi)			Co-60 (nCi)					
		662 keV			835 keV			1173 keV			1332 keV		
		Reference	Measure	Ratio	Reference	Measure	Ratio	Reference	Measure	Ratio	Reference	Measure	Ratio
CZT 1500	**PS 1**	976.9	789	0.81	441.8	469	1.06	876.2	745	0.85	876.2	639	0.73
	PS 2.5		579	0.59		306	0.69		642	0.73		550	0.63
CZT 500	**PS 2.5**		905	0.93		489	1.11		1115	1.27		1154	1.32
*** Ratio = Measure/Reference**													

Table 2 Verification of measurement efficiency

mixed CRM . We know that as PS(Parameter Set) get lower, efficiency become lower. And efficiency of CZT 1500 is higher than CZT500 because pysical size of CZT 1500 semiconductor is larger than CZT500.

In order to verify efficiency of detectors measuring the source terms, we carried out comparative analysis by comparing to reference source terms ^{137}Cs(976.9 *nCi*±20%, 662keV), ^{60}Co(876.2*nCi*±20%, 1173keV, 1332keV) and ^{54}Mn(441.8*nCi*±20%, 835 keV) that is different production date and radioactivity figure.

We found out ratio of measure radioactivity by applying to measure and reference value and we know that the more this ratio value is close to 1, the more measurement efficiency of detector is in good (table 2). We will understand reasons of error in detection efficiency and reduce error bound by more various CRM and a added detector SDP313 later.

3. Conclusions

This study was carried out for finding out detector's efficiency depending on necessary energy in order to save quantitative radioactivity value of source terms. Eventually, this study is to develope CZT Monitoring System measuring CRUD in domestic PWRs primary system or piping system by carrying out in-vivo. Considering error ratio ±20% on radioactivity value of CRM used in measuring and verifying efficiency, measurement of detector Efficiency for the CZT Monitoring System is good. But more various tests is needed than now for an accurate measurement.

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