Study of the triage method for radiological mass casualty event using plastic scintillator

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Abstract

Use of radiation or radioisotopes in the field of industry, medical purpose, research such as non-destructive examination, computed tomography and x-ray, etc. are constantly increasing. With use of nuclear or radiation has incidence possibility for example the Fukushima NPP incident, the Goiania accident and the Chernobyl Nuclear accident. Also the risk of terror by radioactive material such as Radiological Dispersal Device(RDD) and so on. Especially, type of radiological/nuclear accident would be contaminated (internal or external) by gamma-emission radioactive materials. Rapid screening of contaminated people and provide radiological information to medical staff should be primary importance at the radiological incident scene.

In this study is to measure effective detection zone and effective detection activity of plastic scintillation detector(PSD). The plastic scintillation properties are fast response and easy to formation. So we use the PSD to determine contamination or not. Spatial response of a PSD was measured using a Cs-137 check source for various activities (4.44μCi ~ 31.08μCi). For measure the effective detection distance that position of the check source was changed by 0~2 meters high and 0~0.8 meters of side position. It was founded that the optimal position of PSD is 1 meter high and 0.4 meters from side. Changing the distance 0~1 meter from detector, we could obtain the effective detection zone. Based on these results, the effective detection activity was decided by changing activities of check source.

From these experimental results, it was conclude that the response of PSD is influenced by background level, so we should control the standard deviation (δ-value) at high background region. Therefore it will be applicable to rapid screening the contaminated people at radiological incident scene.

Key words: Plastic scintillation detector, mass casualty, effective detection activity, effective detection zone

1. Introduction

As unclear industry grown, 432 of the nuclear power plants are operating and 52 of NPPs are under construction currently[1]. Use of radiation or radioisotopes in the field of industry, medical and research purposes are constantly increasing [2]. With use of nuclear or radiation has incidence possibility for example the Fukushima NPP incident, the Goiania accident and the Chernobyl Nuclear accident. Also the risk of terror by radioactive material such as Radiological Dispersal Device(RDD) etc.

In Korea, since the 'Law on protection of nuclear facilities and countermeasure for radioactive preparedness' was enacted in 2003, the Korean institute of Radiological and Medical Sciences(KIRAMS) was established for the radiation emergency medical response in radiological disaster due to nuclear accident, radioactive terror and so on. Especially National Radiation Emergency Medical Center(NREMC) has the duty that is protect citizens from nuclear, radiological accidents or radiological terrors through the emergency medical preparedness. Normally, internal or external contamination is distinguished by surface contamination monitor or surveymeter directly. However these methods have some disadvantage such as relatively take long time and need for many staffs for operation. Furthermore, the result of these methods could be made a problem at the radiation emergency mass casualty. For overcoming those disadvantages, our institute introduced portable portal monitor for triage contaminated or non-contaminated people at the radiation emergency scene. The portable portal monitor introduce plastic scintillation detector(PSD) which have been widely used for radiation measurement because of their fast response and the relatively low cost, enabling the construction of a large detector system[3]. And it could handle many people (typical count time being one to two seconds) so it is possible to reduce the need of staffs for triage.

In this study, we tried to find effective detection zone of portable portal monitor for triage the contaminated and non-contaminated victims at the radiological mass casualty.

2. Materials and methods

2-1. Portable Portal Monitor

At the radiation emergency, it is very important to distinguish the contaminated or non-contaminated. For this reason, the KIRAMS introduced the portable portal monitor that is Minisentry. It is a sensitive equipment(supplied by CANBERRA Industries) for measuring γ-rays. It was designed to meet the requirements of the contamination monitoring standard for a portal monitor used for radiological emergency response published by the Federal Emergency Management Agency(FEMA) in 1995. It is simple to set up, consisting of four parts- a cross piece, two columns, and a control box. The assembled portal size is 76×203 centimeters for pedestrian especially it can be modified to meet customers' specifications[4, 5]. In normal situation, a portal size will be fixed by a cross piece width(76 centimeters) and for vehicle, the width will be wider than a cross piece size(over 76 centermeters) using vehicle monitoring kit(fig 1). The Minisentry provides three different operational modes those are walk-through, enter-wait and count-rate mode. The walk-through mode and enter-wait modes are suitable for pedestrian traffic while the count-rate mode is used primarily for vehicle traffic. For higher sensitivity or in higher background applications, the enter-wait mode is useful to obtain better sensitivity by requiring a longer count time so it has lower throughput. The walk-through mode provides higher throughput(from 0.1 to 5.0 seconds per person) at a lesser sensitivity, however still meets the FEMA guidelines at normal backgrounds. In the count-rate mode, the fast response time allows for greater sensitivity to changes in monitoring conditions by enabling the unit to respond more quickly to rapid fluctuations in the monitoring environment. And it provides source term information and then takes into account for performance test.

Figure 1. Minisentry–Transportable gamma portal monitor made by CANBERRA industries

2-2. Check Source and plateau curve

Disk type of cesium-137 radiation source was used for measuring the character of portable portal monitor. Half life is 30.2 yr and the radioactivity is 185 kBq(reference date is may 2006).

The plateau process requires both a background plateau with no radioactive source present, and a source plateau which is conducted with a source visible to both detectors. Because the figure of merit compares the relative count rates for the background and the radiation source and recommends a high voltage point that provides the optimum detector sensitivity. Typically, the source is positioned midway between the two detector columns at about the midpoint of the columns. The efficiency value only affects measurements that use activity units.

3. Results

In this study, we measured detection efficiency of portable portal monitor using the radioactive source each point which on the detector surface. Fig. 2 shows that the results of the measured response for the Cs-137 source. Looking at the measured response, three different behaviors are distinguished. Near the PMT, the detection efficiency was dramatically increased. As the source is moving away, the efficiency was sustained similar efficiency level and then slightly decreased[6, 7]. In this result, we consider a ‘transition area’[7] in the detector volume, right next to the PMT. The transition area was therefore considered to start 0.25 meters away from the PMT end and to finish at the 1.5 meters. We found that the transition area of our experiment was found to be in satisfactory agreement with G. Takoudis. et. al[7]. With these result, we considered a center of vertical direction of the detector.

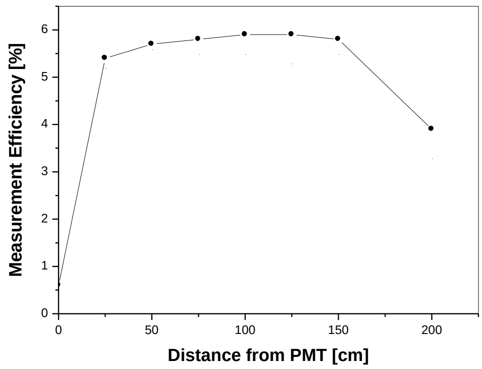

Figure 2. Measured response for a Cs-137 source placed on portable portal monitor - the PMT is positioned top of the detector so, 2 meters from the PMT is the bottom of the detector column.

In order to determine its effective detection zone, we measured detection efficiency of vertical and horizontal direction respectively. At the vertical direction of detector, we divided the length of detector between bottoms to top into eight equal sections at the horizontal direction also divided eight position of horizontal direction between 0 to 0.8 meters. And then efficiency was measured each point. The center of horizontal is 0.4 meters because the portable portal monitor consists of two column detectors.

The measured efficiency which is depends on distance from horizontal and vertical direction of the detector in each position shows Fig. 3. At the horizontal direction, as close to the column(~0.1m from detector) the efficiency was increased. At middle of the detector, the efficiency was sustained similar level. At the vertical direction, around one meter from bottom which is the center of detector indicated the highest efficiency. As observed in Fig. 2, the measured efficiency was decreased near the PMT. So the effective detection zone should be excluded the PMT area and then considered the horizontal and vertical direction. The proposed effective detection zone is inside of two detector columns and from 0.5 to 1.75 meters of vertical direction.

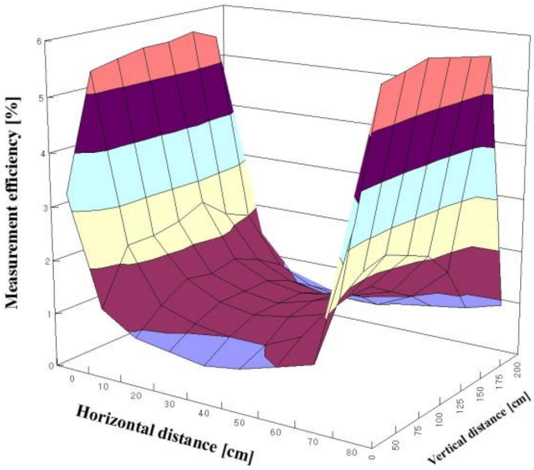

Figure 3. Measured efficiency depend on distance from horizontal / vertical direction of portable portal monitor

For accurate triage the contaminated and non-contaminate people at radiation emergency scene, operator should be considered the effective detection zone. Considering the effective detection zone and then the efficiency was measured by changing activities(16,428 ~ 114,996 kBq). Based on these results, we designed the experimental condition. The center of detector(one meter of vertical direction and 0.4 meter of horizontal direction) was fixed and then the radioactive source was moved from this point up to one meter towards the anterior.

Fig. 4 indicated that the efficiency was increased as the radioactivity was increased. Normally, the radioactivity is in inverse proportion to square of distance, so detection efficiency is in inverse ratio to the distance from detector. However, if the distance was doubled, the efficiency is not quarter precisely(Fig. 4). In the result, the portable portal monitor's detection efficiency was more influenced by activity than distance.

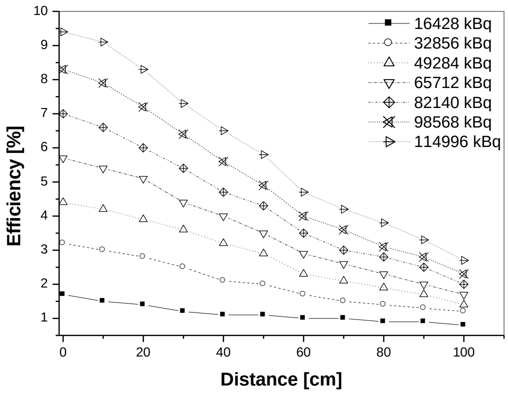

Figure 4. Measured efficiency depends on activity and distance from portable portal monitor

4. Conclusion

The portable portal monitor could be influenced by high background or highly contaminated victim near the equipment. For precise triage at the mass casualty event using portal monitor, operator should understand the performance characters of detector.

In this study, we measured efficiency whole area of detector and then considered the effective detection zone. For setting up the alarm level of the portable portal monitor, the background level must be considered beforehand. Based on these results, the alarm level which is controlled by STD value could be modified more accurately. Therefore it will be applicable to rapid triage the contaminated people at radiological event.

5. References

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