The calibration procedure of the radiation monitoring system installed in radiation controlled area of KOMAC

Sung-Kyun Park [a*], Yi-Sub Min[a], Jeong-Min Park [a], Yong-Sub Cho[a]
[a]*Korea Multipurpose Accelerator Complex, Korea Atomic Energy Research Institute, 181, Mirae-ro, Geoncheon-eup, Gyeongju-si, Gyeongsang buk-do, 780-904, Korea*
[*]*Corresponding author: skpark4309@kaeri.re.kr*

1. Introduction

Korea multi-purpose accelerator complex (KOMAC) operates a 100 MeV high-power proton accelerator, low-energy ion beam facilities, and 1.7 MV tandem accelerator to offer an optimum proton beam and various ion beam services. The spaces, where these accelerators are installed, are defined as the radiation controlled area and the levels of the radiation in this area are monitored by the radiation monitoring system (RMS) to protect radiation workers and experiment users from the hazards of the ionizing radiation [1] and the surface and air contamination tests are carried out periodically by the radiation secure team [2]. Table I shows the classification according to the installation type of RMS installed in the controlled area of KOMAC.

Table I: The device classification of RMS installed in radiation controlled area of KOMAC

Classification by Installation type	Radiation type detected	The number of amount (EA)
Area Monitor	Gamma	52
	Neutron	18
	Hi-energy Neutron	7
Environmental Monitor	Gamma	4
	Neutron	4
Air Effluent Monitor	Particulate and Gaseous	1
Liquid Effluent Monitor	Gross γ	6
Area Monitor	Particulate and Gaseous	2
Hand Foot Monitor		1
Whole Body Counter		1
Total		96

The most of RMS instruments are installed in the accelerator building, where the 100-MeV proton linear accelerator is installed. All detectors of RMS should be calibrated every year to prove the reliability of RMS and almost all instruments for RMS was calibrated during this summer maintenance period of KOMAC this year. Since gamma and neutron area monitors are installed in the space detected the high radiation such as the target room and the accelerator tunnel, the performance check of detectors in the area monitor is the priority of the calibration procedure. In this research, the results of calibration procedure of the gamma and neutron area monitor of the calibration result done in KOMAC are described in focus.

2. Calibration procedure

The gamma and neutron area monitors are installed in the tunnel, the beam line area, the target room and the prepare room of the radiation controlled area, shown in Fig 1. Most of the models of the gamma detector of RMS is Fluke 807A-220 as the geiger-muller detector and the neutron detectors are installed as two kinds of models according the energy range. One is Fluke 943-60 with the energy range between 0.025 eV and 15 MeV and another is Thermo FHT-762 Wendi-2 with the wide energy range between 25 MeV and 5GeV.

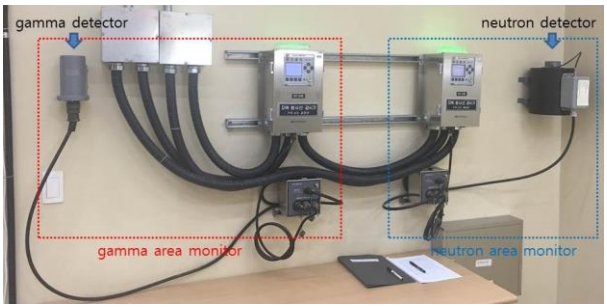

Fig. 1 Gamma area monitor and neutron area monitor installed in the prepare room of radiation controlled area.

Basically, the area monitor consists of detector, preamplifier, and rate-meter called the SRM-200.

In order to calibrate detectors of RMS, the detector calibrated is exposed to the radiation source at computed distances and the reading values of the actual exposure dose rate should be recorded. From the reading values taken, the calibration factor (CF) is calculated as the ratio of theoretical calculated value to the observed value. [3] In order to calculate the radiation dose rate theoretically at the computed distances, there are many complex components considered. In the calibration procedure of KOMAC,

the reference area monitor for the gamma and neutron are selected. The retrospect of these area monitors are maintained to calibrate these area monitors every 5 year from the calibration institute qualified.

2.1 Gamma area monitor

The radiation source to calibrate the gamma detector of RMS is Cs-137 with the activity 740 MBq and a half-life 30.17 year. The production date of this source is 2014-11-07. The front hole of the calibrator, shown in Fig. 2, is produced in conformity with the shape of the Fluke 807A-220 and the gamma radiation source is built in the calibrator. The adaptor shown in Fig2 is used for the gamma detectors with a different form installed in radiation controlled area to be inserted into this calibrator.

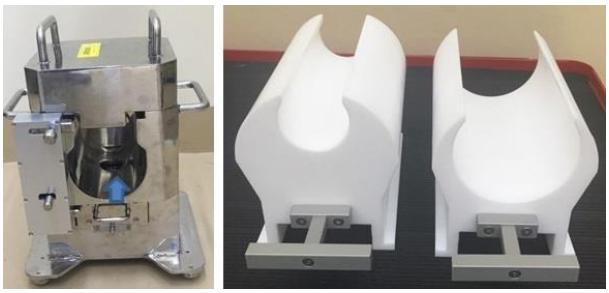

Fig. 2 The calibrator used to calibrate gamma area monitors of RMS. The radiation source is located at the arrow symbol. (The left side) The adaptor used for the calibrator (The right side)

The reference area monitor for the gamma are calibrated from the KAERI and its averaged calibration factor is 0.97 and its relative measure uncertainty is 7.0%. The average of the reference dose rate measured from the reference instrument of the gamma area monitor is 248 μ Sv/h in the low rate mode and 10490 μ Sv/h in the high rate mode. These values are compared with the dose rate values measured from the gamma area monitors installed in the radiation controlled area. The calibration factor and its uncertainty are calculated. The uncertainty is calculated using the following equation (1).

$$U(CF) = \sqrt{U^2(H) + U^2(M) + U^2(CF_{ave}) + U^2(k)} \quad (1)$$

where $U(H)$ is the uncertainty made from the reference area monitor and in this case, the uncertainty 7% mentioned on the calibration certificate published from KAERI will be used. $U(M)$ is the uncertainty made by the data dispersion happened from the 10 times measurement. $U(CF_{ave})$ is the uncertainty made from two uncertainties calculated from the low and high rate mode. $U(k)$ is the uncertainty made from the environmental correction factor such as the distance, temperature, and atmospheric pressure, etc.

2.2 Neutron area monitor

The radiation source to calibrate the neutron detector of RMS is cf-252 with the activity 185 kBq and a half-life 2.645 year. The production date of this source is 2014-11-15. This radiation source for the neutron detector is built in the calibrator, shown in Fig. 2. The radiation source is contacted to the surface of the neutron detector. When the neutron area monitor is calibrated at 2016-07-14, the activity is about 181 kBq. This activity is converted to the reference dose rate using the converting factor. This reference dose rate are compared with the dose rate values measured from neutron area monitors like the gamma case and the calibration factor and its uncertainty are calculated using the equation (1).

Fig. 2 The calibrator used to calibrate neutron area monitors of RMS. The radiation source is located at the arrow symbol. (The left side) The calibrator is attached on the surface of the neutron detector on the calibration procedure. (The right side)

3. Conclusions

Almost all RMS instruments installed in KOMAC is calibrated between 2016-07-13 and 2016-08-24. As the calibration result, if the current reading value are within the 5% of the reference dose rate value, this RMS instrument can be used one more year. Otherwise, the detector of that RMS instrument should be repaired or replaced. The self-calibration certificate for each RMS instrument will be published only for the instrument to satisfy the condition.

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