Easy determination of the state of contamination with a GM counter

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1. ABSTRACT

A GM counter is typically used as a radioactive contaminant monitor in radiation control areas. In most cases, a GM counter represents the value to the counter per second or minute (cps or cpm). However, it is not easy to understand the degree of contamination in a control area using the value (cps or cpm) in a GM counter. The objective of this paper is to develop a rapid determination of the degree of contamination using a GM counter. Permissible surface contamination levels for alpha emitting radionuclides and beta/gamma emitting radionuclides are defined as 4 kBq/m² and 40 kBq/m² under the Atomic Energy Act in Korea respectively. This implies that the unit of value in a GM counter should be changed to kBq/m² for contaminants to be regulated under the Atomic Energy Act. The change of unit can be done when considering the factor of calibration and the detector area. The radiation workers can easily use conversion table attached to the wall in the radiation control area. This effort can provide greater radiation safety control than before.

2. MATERIALS & METHODS

This study used a Geiger-Muller (GM) tube surface contamination counter equipped with a "pancake" probe (Inspector/R, S.E International). The pancake GM tube obtains this nickname from its appearance, because it has a circular disk shape 7cm in diameter, 4cm thick, with an anode pin coming from the side. The GM tube has a graphite-coated mica window with an area of about 20 cm sq. The density of the mica window should be less than 2 mg/cm sq.

Fig 1. Surface contamination monitor
(Type of detector : G-M tube, Model : Inspector/R, Company : S.E. International)

Sample count rate (β)	Detector area	Time of sample counter (t)	Time of BKG (t)	BKG
40.0	20cm²	1min	1 min	45cpm

Table 1. The efficiency of the detector and natural background rate

It is important to consider minimum detectable activity (MDA) in low level counting, as the count rate of a sample is almost the same as the count rate of the background. It is to decide whether or not a given a sample has activity in it. Therefore, the lower limit of detection (LLD) and MDA are given by This is an incomplete sentence.

$$LLD = \frac{2.71}{T_s} + 4.653\frac{\sqrt{N_b}}{T_b} \quad - (1) \qquad MDA = \frac{\frac{2.71}{T_s} + 4.65\frac{\sqrt{N_b}}{T_b}}{E \times A} \quad - (2)$$

where,

T_s : Time of the sample count;

T_b : Time of the background count;

N_b : Count rate of the natural background ;

E : Detection efficiency of the counter; and

A : Area monitored or wiped,

Determining the LLD or MDA requires the following information regarding the performance of a survey meter or counting system
- The normal background count rate
- The counting efficiency of the meter or counting system for the radioisotope being measured
- The effective surface area of the detector probe (for portable survey meters)

The meter's LLD and counting efficiency must be known for the radioisotopes routinely used in a laboratory. Permissible surface contamination levels for alpha emitting radionuclides and beta/gamma emitting radionuclides are defined as 4 kBq/m² and 40 kBq/m² under the Atomic Energy Act in Korea respectively. The surface contamination level must be under the overall contamination level.

When changing the unit of value in a GM counter, it is difficult to directly estimate the degree of contamination using cps in a laboratory where unsealed sources are used. Thus, after calibrating a counter, the degree of contamination can be calculated as follows using the efficiency, surface area of the counter, and conversion factor.

$$the\ level\ of\ contamination(\frac{Bq}{cm^2}) = \frac{cpm}{efficency \times area(cm^2) \times factor\ of\ conversion} \quad - (3)$$

An employee cannot calculate the equation. If the conversion table of the contamination level is made in advance, it is easy to realize the degree of contamination in the control area. If the value in the GM counter is 600 cpm, the unit can be changed as follows:

$$\frac{600cpm}{40\% \times 20cm^2 \times} = 1.25(\frac{Bq}{cm^2}) \quad - (4)$$

The conversion table can be obtained from equation 3.

No.	counting rate (cpm)	level of contamination (Bq/cm²)	No.	counting rate (cpm)	level of contamination (Bq/cm²)	No.	counting rate (cpm)	level of contamination (Bq/cm²)	No.	counting rate (cpm)	level of contamination (Bq/cm²)
1	100	0.208	11	600	1.250	21	1100	2.292	31	1600	3.333
2	150	0.313	12	650	1.354	22	1150	2.396	32	1650	3.438
3	200	0.417	13	700	1.458	23	1200	2.500	33	1700	3.542
4	250	0.521	14	750	1.563	24	1250	2.604	34	1750	3.646
5	300	0.625	15	800	1.667	25	1300	2.708	35	1800	3.750
6	350	0.729	16	850	1.771	26	1350	2.813	36	1850	3.854
7	400	0.833	17	900	1.875	27	1400	2.917	37	1900	3.958
8	450	0.938	18	950	1.979	28	1450	3.021	38	1920	4.000
9	500	1.042	19	1000	2.083	29	1500	3.125	39	2400	5.000
10	550	1.146	20	1050	2.188	30	1550	3.229	40	2880	6.000

Table 2. An example of the Conversion table of the measuring count to contamination level

3. Results & Discussion

The change of unit can be done when considering the detection area and factor of calibration. The degree of contamination is readily understood using equation 3 and Table 2. The radiation workers in the site can easily use the created conversion chart placed on the wall in the radiation control area. This effort can provide a method of radiation safety control.

4. Conclusions

It is easy to check the contamination in the control area using a conversion table. When applying this study in the control area, it is necessary to consider a constant distance between the counter and surface. This study showed whether the elucidation of radioactive contamination in the control area using a rapid determination method was successful. In addition, the reliability of a counter was enhanced for the management of radiation safety control.

5. References

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