Health physics practice for some gamma sources

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Abstract

The radioactive decay law was used to calculate their twenty present activities from the four ^{137}Cs, four ^{60}Co,two ^{210}Po,two ^{90}Sr,two ^{204}Tl, ^{22}Na, ^{24}Na, ^{57}Co, ^{54}Mn, ^{133}Ba and ^{109}Cd standard gamma sources of having different manufacture dates in Experimental Nuclear Physics Laboratory, Physics Department, Yadanabon University, Myanmar for the experiment day in February 2020. The radiation contamination meter (digital Frisker survey monitor) was used to measure the dose rates from ^{57}Co, ^{60}Co, ^{137}Cs and ^{133}Ba gamma sources placing at eight different positions of four quadrants in circular form for laboratory monitoring. The isodose lines verifying the inverse square law relationship of radiation dose rates from the four gamma sources were done for health physics practice.

Keywords: radiation contamination meter, gamma sources

Introduction

Health physics is a field of science concerned with radiation physics and radiation biology with the goal of informing the safe use of ionizing radiation. Radiation workers should make a habit of frequently checking their workplace with a health physics instrument, in order to detect contamination. A health physics instrument is a device that can provide information about the dose rate or dose at the location where the instrument is placed. Health physics instruments are divided into two general groups according to the way they are used. They are survey instruments (portable and nonportable) and personnel monitoring instruments (dosimeters).

There are twenty gamma sources in the Experimental Nuclear Physics Laboratory, Physics Department, Yadanabon University, Myanmar. Three sources ^{137}Cs, ^{60}Co and ^{24}Na were manufactured by the year 2018.The five sources ^{137}Cs, ^{210}Po, ^{60}Co, ^{90}Sr and ^{204}Tl were manufactured by the year 2016. The five sources ^{137}Cs, ^{210}Po, ^{60}Co, ^{90}Sr and ^{204}Tl were manufactured by the year 2012.Seven sources ^{22}Na, ^{57}Co, ^{137}Cs, ^{60}Co, ^{54}Mn, ^{133}Ba and ^{109}Cd were manufactured by the year 2008.

The main objective of health physics programme is to reduce personal exposure, both external and internal, to a minimum by knowing the present activity of used standard gamma source while doing any research and to determine the dose rates from the four sources (MD 2008) of very low strength. It is aimed for obeying safety in the Nuclear Physics Laboratory, Yadanarbon University.

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In the practice, the potable survey meter was used to measure the isotropic dose rates from lowest activity of ^{57}Co, ^{60}Co, ^{137}Cs and ^{133}Ba gamma sources at the laboratory in 2012.The aim of this research is to be familiar with using radiation contamination meter (digital Frisker survey monitor) and to study the detection and measurement in isotropic emission of gamma radiations for areas of work associated with radiation protection in good health physics practice.

Theoretical Background

Radiation from a Point Source

If the radiation emanates from a point source which emits the radiation isotropically, the dosage received at a point in space will also depend on its distance from the point source. The activity of the substance A, is always proportional to the total number of nuclei, N, still present at time is represented by $A = A_0 \exp(-\lambda t)$. The energy flux or radiation intensity is defined by $I = \Phi E = SE / 4\pi d^2$.If μ is the linear energy absorption coefficient, the dose rate R at which energy is absorbed per cubic centimeter of material from the incident radiation is by the equation $R = \mu \Phi E$ and $R = \mu I$. The main parameters upon which protection from external radiation depends are intensity, time, distance and shielding.

Materials and Methods

Exempt Quantity Sealed Gamma Sources

The following sources, mounted in 2.5 cm diameter sealed plastic disks, are exempt from USNRC and state licensing present no special storage or dispersal requirements. The radioactive material contained in the package is an exempt quantity from USNRC and Agreement State licensing requirements. The radiation exposure rate at any point on the external surface of the package does not exceed 0.5 milli rem/hour. No other hazard labeling and shippers declarations are required or authorized. These sources are usually used for checking the performance of GM and NaI(Tl) detectors. Solid sealed exempt quantity sources require no special handing. All radioactive materials should be securely stored when not in use. The structure of a sealed source is given in Table (1). The photograph of the three sources manufactured by the year 2018 is shown in Figure (1).The photograph of the five sources manufactured by the year 2016 is shown in Figure (2). The photograph of the five sources manufactured by the year 2012 is shown in Figure (3). The photograph of the seven sources manufactured by the year 2008 is also shown in Figure (4).The present activities of the twenty gamma sources were calculated by using radioactive decay law for the experiment day in February 2020.

Radiation Contamination Meter (Digital Frisker Survey Monitor)

Small Digital Rate meter with separable 2″diameter pancake probe is read out in mR/hr(Optional μSv/h or cpm /cps). Thin probe window is recessed and protected by sturdy stainless steel grill. Instrument will see alpha, beta and gamma radiation. Anti–saturation circuit will not fall below full scale in high fields. Tested to 100 R/ hr. Sonalert gives audible rate indication. The specification of the survey monitor is represented in Table (2). The photograph of radiation contamination meter is also shown in Figure (5).

To find out the variations of gamma radiation dose rate using radiation contamination meter and four gamma sources (MD 2008), the practices were done in Experimental Nuclear Physics Laboratory, Physics Department, Yadanabon University in December 2012. The four gamma sources were ^{57}Co (27×10^{-6}μCi), ^{60}Co (0.233μCi), ^{137}Cs (0.775μCi) and ^{133}Ba (0.481μCi).The experiment includes the following equipments. They are the model TBM – 15D digital frisker survey monitor with separable GM probe, gamma source, stop watch and a half meter stick. Firstly the various knobs and switches on the panel of instrument were studied carefully and battery was also checked. Four experiments of four sources were done in the whole experimental procedure. There are four measurements for quadrants I, II, III and IV in each experiment. Each source was fixed at the centre of the circle drawn on the paper throughout each experiment. Each counting time was 60 seconds and recorded with stop watch. The survey monitor and stop watch were switched on simultaneously. The maximum count was taken in each counting.

By using ^{57}Co source, the first experiment was done in the following procedure. In the first quadrant, the GM probe was placed at 2cm away from the source. The survey monitor counted the rate of the incoming radiation for 60 seconds. The probe was moved 1cm increment to 3cm, 4cm, 5cm, 6cm, 7cm and dose rates were recorded. Then the dose rates were marked when the probe was changed 2cm increment to 9cm and the probe was transferred 3cm increment to 12cm. The next three measurements were done in order to get the dose rates of eight positions in II, III, IV quadrants. This is the end of the first experiment. Since the counts on eight positions in four quadrants were found to be nearly equivalent, the average dose rate was taken in one circle path. Similarly, the second experiment was accomplished by using ^{60}Co source. Third experiment was finished by using ^{137} Cs source. Fourth experiment was also completed by using ^{133} Ba source. The experimental set–up is illustrated in Figure (6).

Table (1) Structure of a Sealed Source

Overall Dimension		
Overall Diameter	Active Diameter	Height
1''	0.197''	0.250''

Figure (1) Photograph of Sealed Three Gamma Sources Manufactured by 2018

Figure (2) Photograph of Sealed Five Gamma Sources Manufactured by 2016

Figure (3) Photograph of Sealed Five Gamma Sources Manufactured by 2012

Figure (4) Photograph of Sealed Seven Gamma Sources Manufactured by 2008

Table (2) Specification for Digital Frisker Survey Monitor

Read –out:	Rugged 6 digit display.
Ranges:	0.01 to 100 mR⁄hr, no range switching.
Battery Test:	Push button.
Audio:	Sonalert.
Detector:	T–1190 2″ diameter (5cm) pancake GM tube.Window Diameter: 1 3⁄4″, 4.5 cm. Window Thickness: 1.5 mg⁄cm^2.Quench Gas: Halogen for long life. Background: Typical 50cpm.Thin profile of tube (13mm gives low background) Efficiency: 100% for all betas and alphas that have sufficient energy to penetrate the thin window.
Physical Dimensions:	3″; 7.6 cm wide × 5 1⁄4″ W; 1.33 cm long ×2 1⁄4″; 6 cm thick (excluding probe, meter, and handle).
Calibration:	Single master calibration pot as well as programmable calibration factor.
Power:	6 ″AA″ cells.
Weight:	Electronics only: 22 oz.; 625 gm. Total: including separable pancake probe 34 oz.; 0.97 kg.
Battery Life:	1 hour in normal operation (longer with Li or NiMH Battery).

Figure (5) Photograph of Radiation Contamination Meter

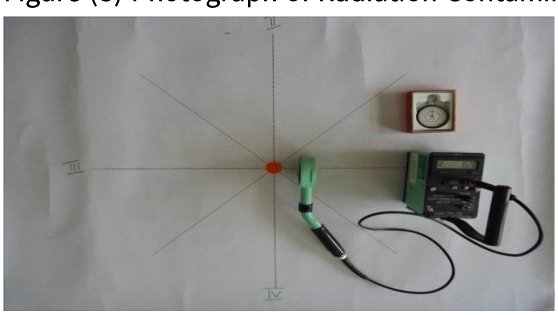


Figure (6) Photograph of Experimental Set–up

Results and Discussions

The present activity data of twenty gamma sources for February 2020 in Physics Department, Yadanabon University, was calculated in Table (3). The measurements of the dose rates of the four gamma sources placing at eight positions were done by using the radiation contamination meter. The counts on eight positions in four quadrants were found to be nearly equivalent. The dose rate data for ^{57}Co, ^{60}Co, ^{137}Cs and ^{133}Ba sources were listed in Table (4) to Table (7). The dose rates decrease with the increasing distances and spread isotropically. The isodose lines for ^{57}Co, ^{60}Co, ^{137}Cs and ^{133}Ba sources were illustrated in Figure (7) to Figure (10). The four isodose lines show equal dose rates in equal distances of four quadrants by circular form. The dose rates were found to be in isotropic emission and obeying with the fact that the dose rate is in inverse proportion to the square of the distance.

Table (3) Present Activity Data for Twenty Gamma Sources in Physics Department Yadanabon University

No	Type of Element	Half– Life	Manufacture Date	Standard Activity (μCi)	Present Activity (μCi)
1	^{137}Cs	30.07 years	Feb 2018	5	4.775
2	^{60}Co	5.27 years	Feb 2018	5	3.848
3	^{22}Na	2.6 years	Feb2018	5	2.931
4	^{137}Cs	30.07 years	July 2016	0.25	0.230
5	^{210}Po	138.4 days	Sept 2016	0.1	0.002
6	^{60}Co	5.27 years	Sept 2016	1	0.639
7	^{90}Sr	28.8 years	Sept 2016	0.1	0.092
8	^{204}Tl	3.78 years	Sept 2016	0.25	0.134
9	^{137}Cs	30.07 years	June 2012	5	4.191
10	^{210}Po	138.4 days	June 2012	0.1	8.398×10^{-8}
11	^{60}Co	5.27 years	June 2012	1	0.366
12	^{90}Sr	28.8 years	June 2012	0.1	0.083
13	^{204}Tl	3.78 years	June 2012	1	0.246
14	^{22}Na	2.6 years	June 2008	1	0.044
15	^{57}Co	271.8 days	June 2008	1	1.934×10^{-5}
16	^{137}Cs	30.07 years	May 2008	1	0.763
17	^{60}Co	5.27 years	May 2008	1	0.215
18	^{54}Mn	312.3 days	May 2008	1	7.442×10^{-5}
19	^{133}Ba	10.5 years	May 2008	1	0.460
20	^{109}Cd	464 days	May 2008	1	0.002

Table (4) Dose Rate Data for ^{57}Co Source

No	Distance (cm)	Dose Rate (mR/h)				
		First Quadrant	Second Quadrant	Third Quadrant	Fourth Quadrant	Average Measurement
1	2	0.05	0.05	0.05	0.05	0.05
2	3	0.04	0.04	0.04	0.04	0.04
3	4	0.03	0.03	0.03	0.03	0.03
4	5	0.02	0.02	0.02	0.02	0.02
5	6	0.02	0.02	0.02	0.02	0.02
6	7	0.02	0.02	0.02	0.02	0.02
7	9	0.02	0.02	0.02	0.02	0.02
8	12	0.02	0.02	0.02	0.02	0.02

Table (5) Dose Rate Data for ^{60}Co source

No	Distance (cm)	Dose Rate (mR/h)				
		First Quadrant	Second Quadrant	Third Quadrant	Fourth Quadrant	Average Measurement
1	2	1.16	1.12	1.11	1.12	1.13
2	3	0.96	0.89	0.92	0.89	0.92
3	4	0.76	0.79	0.77	0.69	0.75
4	5	0.61	0.56	0.55	0.58	0.58
5	6	0.43	0.42	0.44	0.45	0.44
6	7	0.38	0.36	0.35	0.36	0.36
7	9	0.20	0.24	0.25	0.22	0.23
8	12	0.16	0.15	0.17	0.16	0.16

Table (6) Dose Rate Data for ^{137}Cs Source

No	Distance (cm)	Dose Rate (mR/h)				
		First Quadrant	Second Quadrant	Third Quadrant	Fourth Quadrant	Average Measurement
1	2	4.80	4.68	4.42	4.92	4.71
2	3	3.18	3.21	3.10	3.30	3.20
3	4	2.01	1.97	2.20	2.14	2.08
4	5	1.34	1.56	1.33	1.41	1.41
5	6	0.84	0.86	0.92	0.87	0.87
6	7	0.76	0.79	0.72	0.71	0.75
7	9	0.40	0.42	0.41	0.38	0.40
8	12	0.21	0.24	0.25	0.21	0.23

Table (7) Dose Rate Data for ^{133}Ba Source

No	Distance (cm)	Dose Rate (mR/h)				
		First Quadrant	Second Quadrant	Third Quadrant	Fourth Quadrant	Average Measurement
1	2	0.56	0.52	0.57	0.56	0.55
2	3	0.39	0.39	0.40	0.40	0.40
3	4	0.30	0.29	0.32	0.29	0.30
4	5	0.20	0.23	0.24	0.19	0.22
5	6	0.17	0.20	0.17	0.18	0.18
6	7	0.13	0.15	0.15	0.13	0.14
7	9	0.10	0.12	0.10	0.11	0.11
8	12	0.08	0.09	0.07	0.08	0.08

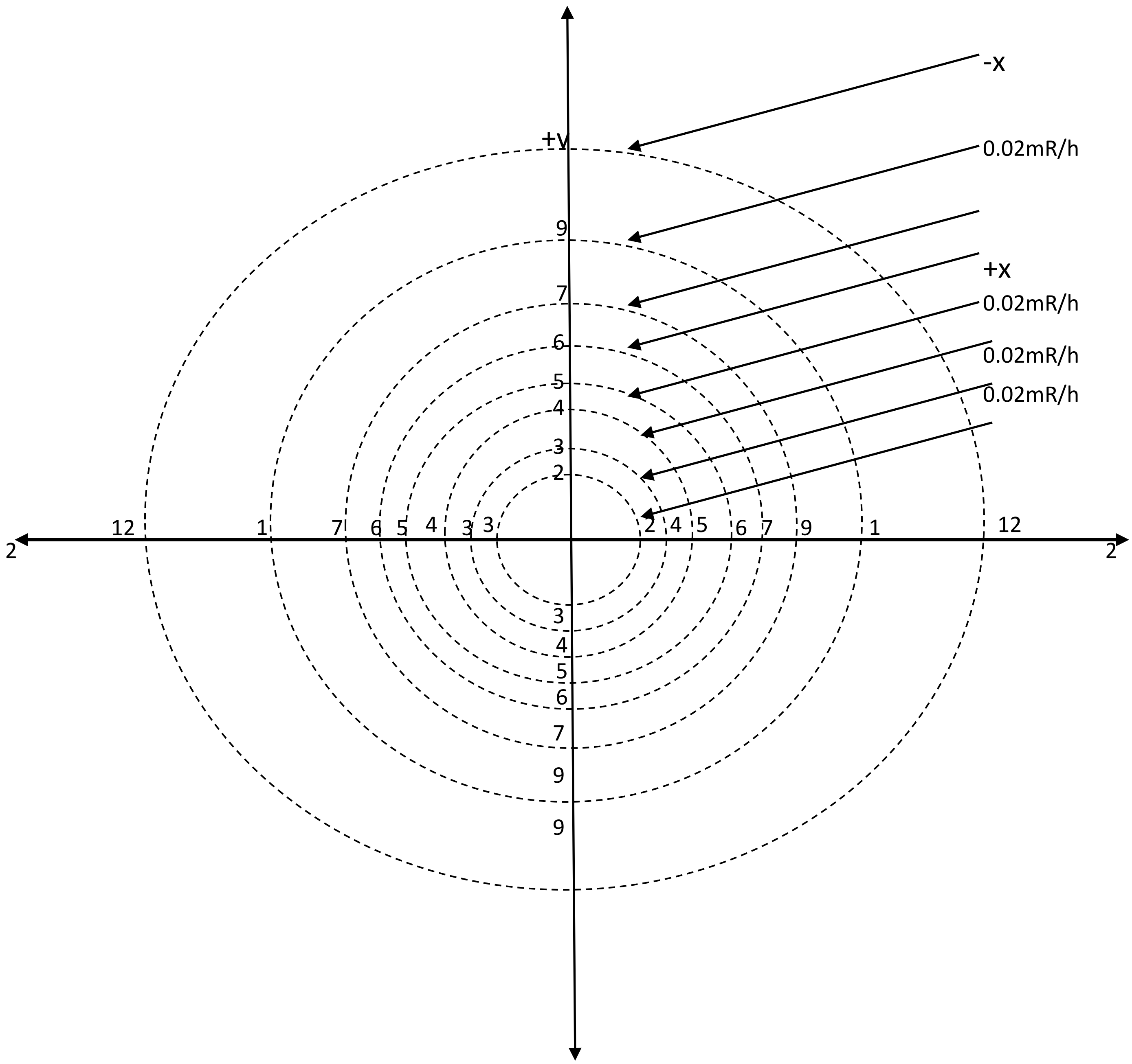
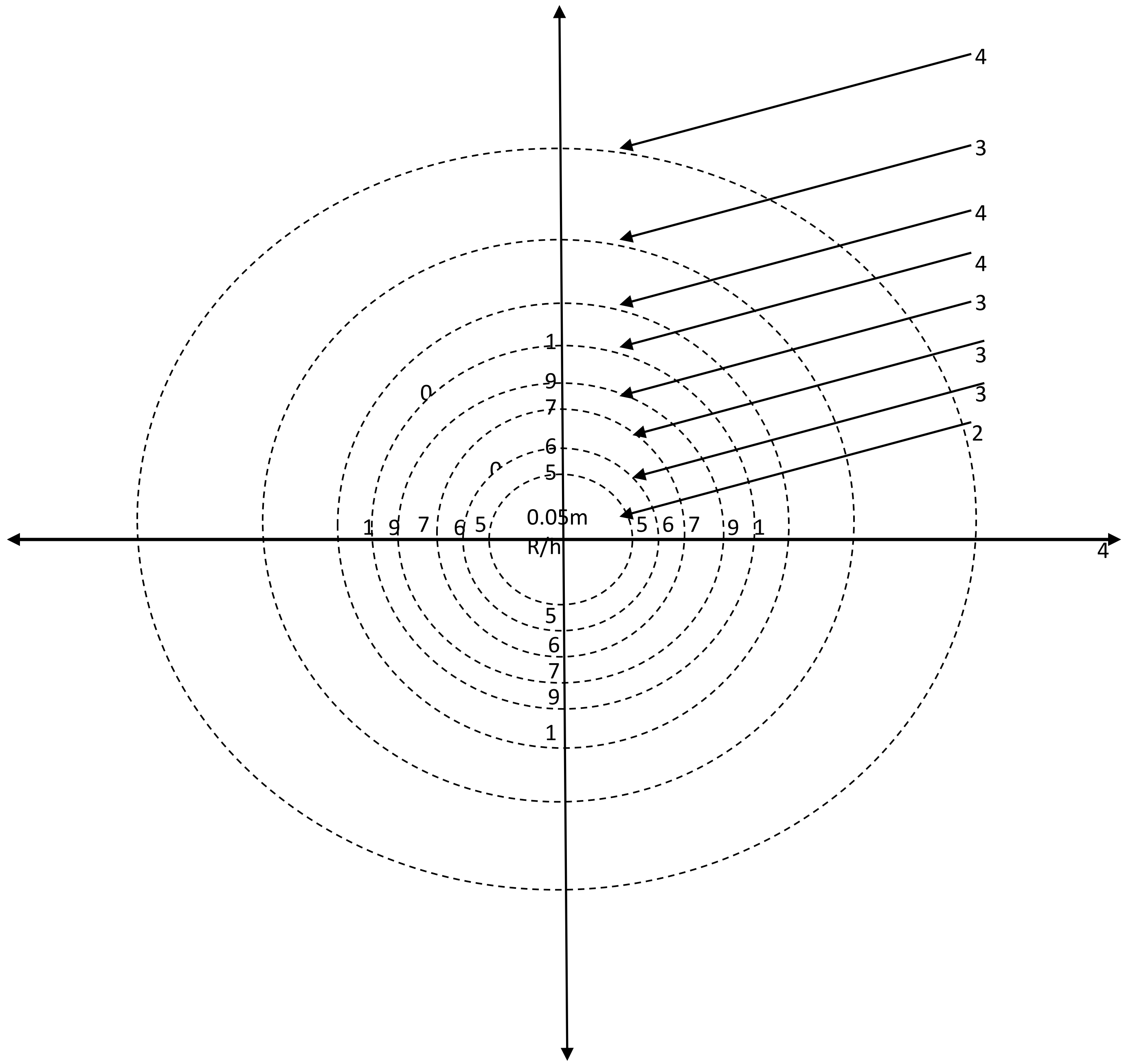


Figure (7)Isodose Lines for ^{57}Co Gamma Source



Figure(8) Isodose Lines for ^{60}Co Gamma Source

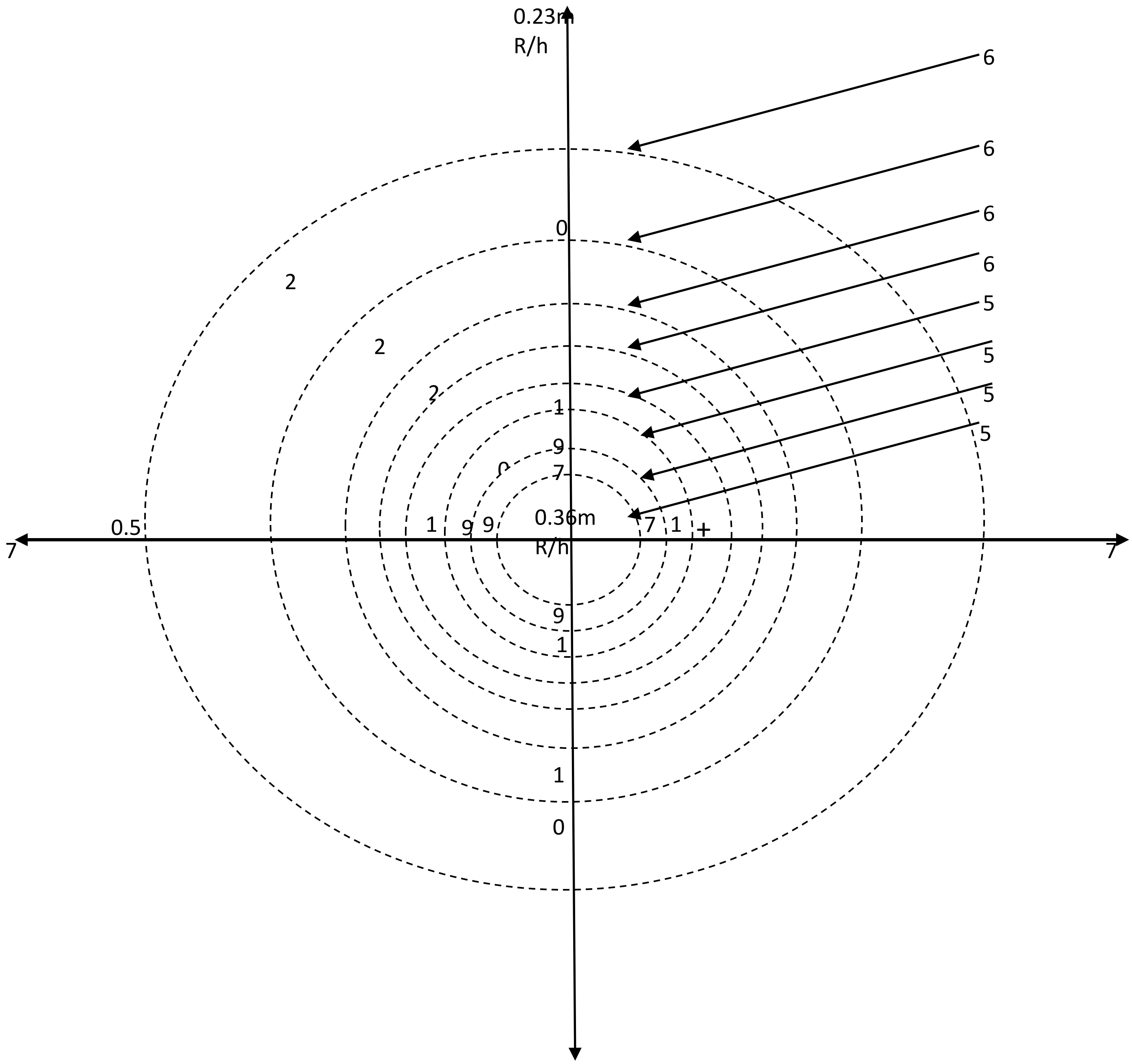


Figure (9)Isodose Lines for ^{137}Cs Gamma Source

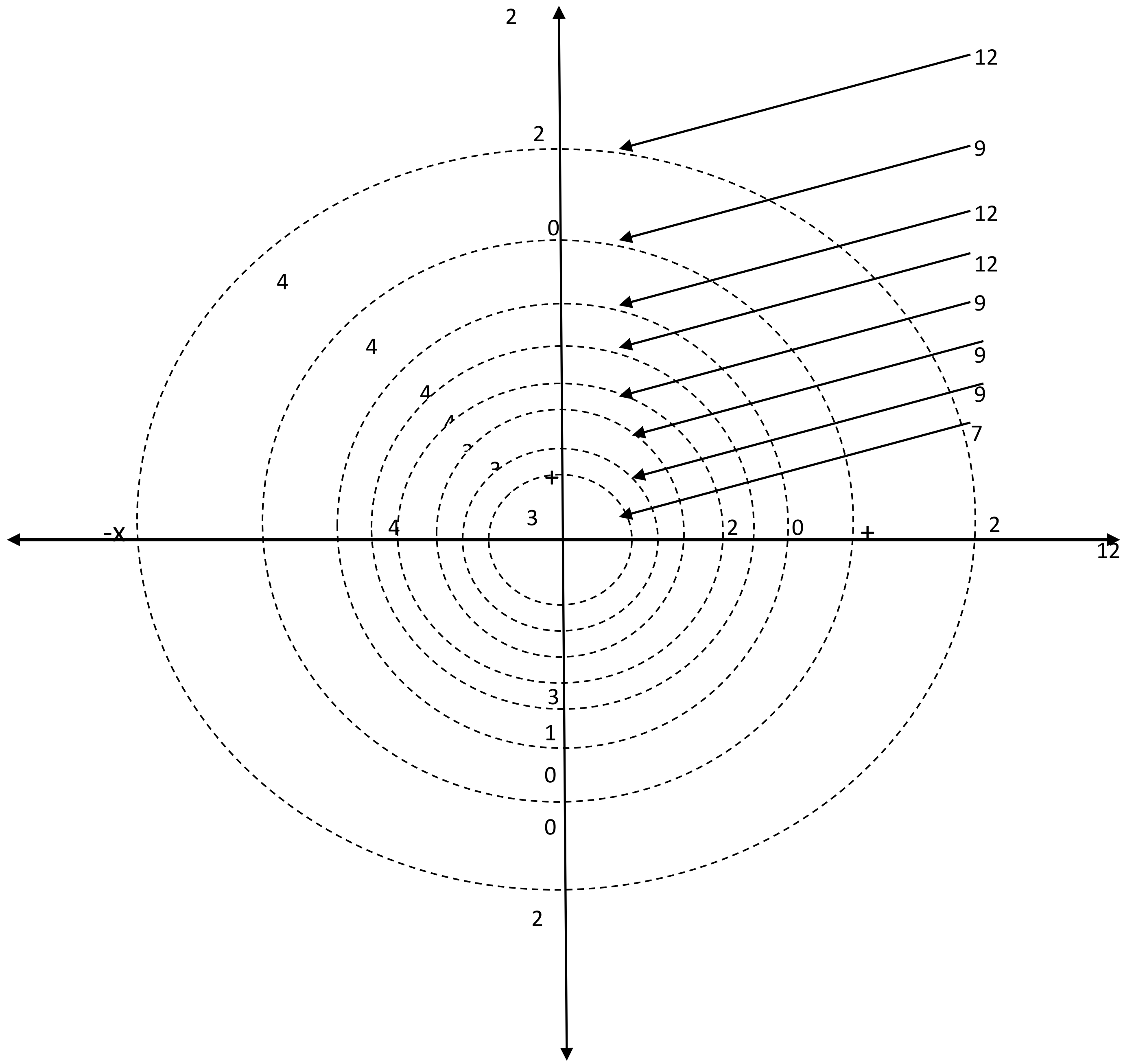


Figure (10)Isodose Lines for ^{133}Ba Gamma Source

Conclusion

Health physics is concerned with protection of people from man–made radiation. In any laboratory where radioactive sources are used, everyone should be aware of, and use good health physics practices. Twenty gamma sources in Experimental Nuclear Physics Laboratory, Physics Department, Yadanabon University are sealed and have low activity, so they do not present a real health physics problem. Four sources that are used for the practice have very low activities. The gamma sources manufactured by 2008 are not suitable for use now.For the experiments that require higher activity sources, the particular safety techniques should be used in setting up and performing the experiment.

Since radiation cannot be felt or detected by our sense, measuring the existence and amount of radiation by using the survey monitor is a step to detect the contamination in the laboratory. The Digital Fricker Survey Monitor can be used to check for surface contamination on a floor, tables and any other goods, but, when the dose rate in the vicinity is high. So this Geiger Muller counter type survey meter is easy to measure the dose rate in working areas.

Nevertheless, unnecessary exposure should be avoided and to ensure that this risk be kept at a minimum, a few safely precautions should be followed.

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References

"AN–34", ORTEC Application Note, Second Edition; 1976,.

Japan Radioisotope Association (JRIA), Basic Knowledge of Radiation and Radioisotopes; 2005.

Radiation Contamination Meter(Digital Frisker Survey Monitor) Model TBM–15D Manual.

Tsoulfanidis N.Measurement and Detection of Radiation, USA; 1995.