Use of Sealed Radioactive Sources for Teaching Purpose in Schools

CONTENTS

Science Education Section
Education Bureau

Notes on "Code of Practice on the Use of Sealed Radioactive Sources for Teaching Purposes in Schools"

This article should be read in conjunction with the above mentioned Code of Practice (Appendix 1). The aim is to illustrate how SI units are converted from the traditional units and how routine checks can be carried out at intervals not exceeding 12 months under the supervision of the radioactive source custodian. Specifications of the storage cupboard and the radioactive source lifting tool, samples of the record form for storage of radioactive sources, and exemption form requiring radioactive substances licence are also included.

Schools shall only possess the type and quantity of radioactive sources listed in the exemption notification granted by Radiation Board.

(A) SI unit of radioactivity measured: becquerel

In expressing the activity of a radioactive source, the traditional unit is the curie (Ci), defined as 1 curie = 3.7×10^{10} disintegration per second.

The SI unit of radioactivity measured is the becquerel (Bq) and

1 Bq = 1 disintegration per second.

For conversion, 1 Ci = 3.7×10^{10} Bq

1 μCi = 3.7×10^{4} Bq or 37 kBq

The commonly available sources in the school Physics laboratory have an activity of 5 μCi.

Thus 5 μCi = 5 x 37 kBq
= 185 kBq

To make an approximation for easy reference, the Radiation Board has recommended the following conversions:

Original Activity	Converted Activity (approximated values)
0.002 μCi	75 Bq
0.02 μCi	750 Bq
0.125 μCi	5 kBq
5 μCi	200 kBq
9 μCi	350 kBq

(B) Routine checks of monitoring instruments

The common monitoring instrument possessed by the school Physics laboratory consists of a G-M tube (GM tube) connected to a scaler. The Mullard type ZP1481 (MX 168) GM tube, a halogen-quenched tube sensitive to β - and γ - radiation and high energy α - particle is recommended as a general purpose radioactive detecting tube in the *Reference List of Furniture and Equipment for Secondary School: SS Physics*. The tube has a robust body with a thin mica end window fitted with a removable protective open mesh plastic cap. The construction of the tube determines its high sensitivity to β - radiation.

The custodian may follow the working schedule (in the form of a worksheet) as shown in Appendix 2. Results of a typical experiment are shown in the worksheet for teachers' reference.

The graph of count-rate against applied voltage is called the characteristics curve of the GM tube. *The length and slope of the plateau are criteria used to assess the efficiency and condition of the tube*.

For normal counting purposes, the working voltage V_w is usually set at a value about 50 V higher than the threshold voltage V_T (i.e. $V_w = V_T + 50$ V). At the working voltage, small fluctuations in the applied voltage will not cause significant deviations in count-rate. In routine checks of sources, the GM tube should be set at the working voltage found in this experiment.

(C) "Wipe Test"

Routine checks on the sealed radioactive sources are mainly tests for leakage or surface contamination of such sources. The "Wipe Test" is the recommended test for sources available in the school Physics laboratory. The entire external surface of the sealed source should be wiped with material (e.g. swab, tissue or cotton bud) moistened with a liquid which is effective in removing the radioactive material involved. The liquid should not attack the container or any bonding material. Ethanol or water is recommended in the code of practice. *The radioactivity removed is measured and its value should be less than 200 Bq*. In this case, the source may be considered to be free from leakage. Otherwise, any source failing the routine checks should be considered as defective. Such sources should be withdrawn from use.

The working schedule shown in Appendix 3 may be used as a worksheet for the custodian to carry out the "Wipe Test". Sampele results are also shown for teachers' reference.

(D) Irregularity

In case there is any irregularity found in the routine checks or any sealed source identified as defective, the paragraphs 2.5, 5.1 and 5.2 of the code of practice (reproduced below) should be referred.

2.5 All sealed sources failing the routine checks shall be considered as defective and withdrawn from use until proven otherwise by a competent laboratory approved by the Radiation Board.

5.1 Retention of defective, obsolete or unnecessary sources of radiation is undesirable and positive steps shall be taken for the safe disposal of such sources. They shall either be returned to the suppliers and the Radiation Board notified; or be disposed of in a manner approved by the Radiation Board.

5.2 In the event of damage to, or loss of any sources, the following shall be notified immediately:

Physicist on-duty (Tel: 7110 3382 call 1912) and
Occupational Health Officer, Labour Department(First Call Tel: 9689 0378; Second Call Tel: 9689 0450)

In all cases, the Secretary of Radiation Board shall be notified in writing within 48 hours.

(E) Radioactive source record

A blank form on "Sealed Radioactive Source Record" (Appendix 4) is included for schools to make photocopies for their own use. A sample record of a typical source is also attached for teachers' reference. It is essential for each individual sealed radioactive source to have its own record.

(F) Logbook

All the results of the routine checks shall be entered into a logbook which shall be made available for inspection by the Radiation Board on request.

(G) Storage cupboard

It was stipulated in the Code of Practice that all sealed sources shall be kept in a locked metal container with an appropriate warning label outside. The purpose of the container is to prevent unauthorized access to the radioactive sources and to avoid dispersion of the radioactive materials in case of fire. It is therefore desirable that all radioactive materials should be stored in the metal container. The metal storage cupboard suitable for this purpose, is available from usual scientific equipment suppliers and its description can be found in Appendix 5. As the sealed sources are pointed downwards during storage, it is recommended that the cupboard be sited close to the floor.

(H) Radioactive source lifting tool

The radioactive source lifting tool with spring holder type is recommended for extracting the sealed sources by the stem (4 mm diameter) and for holding the sources during some experiments. The descriptions of the tool can be found in Appendix 6. In some cases, the lifting tools were delivered to the school without the wire loop holding the two arms together which renders the spring action not operative. This can be easily remedied by the addition of a thin metal wire loop at the position indicated in the diagram in Appendix 6.

Appendix 1

Code of Practice on the Use of Sealed Radioactive Sources for Teaching Purposes in Schools

The use of radioactive sources for teaching purposes is governed by the *Code of Practice on the Use of Radioactive Sources* for Teaching Purposes in Schools which was issued by the Radiation Board. The Code of Practice is reproduced below for reference.

1. General Rules

1.1 Students should not be exposed to ionising radiation unless there is a valid reason for doing so; demonstrations and experiments that result in exposure should be relevant to the course of instruction. Any such exposure shall be kept to as low as reasonably achievable.

1.2 The use of sealed radioactive sources ("sources") in schools shall be solely for the performance of simple experiments to demonstrate fundamental principles, and the sources used and the methods of using such sources shall be such as to ensure that the degree of hazard is very small.

1.3 No demonstrations or experiments involving the deliberate exposure of students, staff or any other person to ionising radiation shall be performed.

1.4 Experiments should be carefully planned to minimize the exposure time, and preliminary rehearsals of the experiment procedure using simulated sources should be encouraged.

2. Control of Sources

2.1 The Radiation Board is the statutory body which controls the use and/or possession of radioactive substance and irradiating apparatus in Hong Kong. Schools deciding to avail themselves of the opportunities to possess and use sources for teaching shall apply to the Secretary, Radiation Board, 3/F., Sai Wan Ho Health Centre, 28 Tai Hong Street, Sai Wan Ho, Hong Kong, for exemption from requiring radioactive substances licence if the total quantity of radioactive substances does not exceed the limit specified in Section 3 below.

2.2 It shall be the responsibility of a graduate member of the science staff, who shall be designated the source custodian, to supervise the use of all radioactive sources within the school. Should the source custodian leave the school for any reason, a fresh application for exemption will have to be made in respect of the newly appointed source custodian.

2.3 The source custodian shall be responsible for the procurement, storage, issue and return of sources, the correct use of all sealed sources, and the disposal of sources.

2.4 The source custodian shall arrange for routine checks, at intervals not exceeding 12 months, of the condition of all sealed sources by wipe test and the efficiency of monitoring instruments. All the results shall be entered into a logbook which shall be made available for inspection by Radiation Board on request. (*Wipe test -The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured. Acceptance limit : 200 Bq)

2.5 All sealed sources failing the routine checks should be considered as defective and withdrawn from use until proved otherwise by a competent laboratory approved by the Radiation Board.

2.6 The teacher-in-charge of a class shall account for all sealed sources before the period of instruction is concluded.

2.7 Sealed sources should be used by a student only when under the direct supervision of a teacher.

2.8 The immediate responsibility of radiation safety in any experiment involving ionising radiation shall rest with the teacher-in-charge.

2.9 No sources shall be taken out of the school premises approved by the Radiation Board.

3. Storage and Labelling

3.1 Maximum amount in store:
The type, quantity and activity of sources kept in a school laboratory should be the minimum practicable and shall in all cases be no greater than the following exemption limit:

Sealed sources	Quantity
Cobalt-60, Strontium-90, Radium-226, Americium-241	• Not more than two sources for each type • Each source not exceeding 200 kBq in activity
Insoluble radium-226 sources to be used with diffusion cloud chamber	• Not more than 10 such sources • Each source not exceeding 750Bq in activity

Remarks: Should a school wish to use other sources or radioactive substances not in *Handbook on Safety in Science Laboratories* issued by the Education Bureau, the school shall apply to the
Radiation Board for a licence (Tel: 3620 3746)

3.2 All sealed sources shall be kept in a locked metal container.

3.3 Access to this container shall be limited to authorised staff member of the school.

3.4 The metal container shall be permanently labelled in such a manner to indicate that it contains radioactive substances.

3.5 Individual sources shall be stored in separate, appropriately labelled container or compartments within the locked metal container.

3.6 Each source shall be easily identifiable by the user.

3.7 Sources and their containers should be permanently labelled with the type of radionuclide together with the activity at a specified date.

4. Handling of Sources

Sealed radioactive sources shall be handled with care and unnecessary handling of sources shall be avoided. The following rules should apply:

4.1 Sources should be transported between the laboratory and their place of storage within the same school premises in their dedicated containers.

4.2 Sources should only be handled by tongs or forceps. Teachers should note that specially designed tongs for the safe handling of sources are available from commercial suppliers.

4.3 Alpha-emitting sources should be handled with extreme care because of the necessarily fragile nature of their construction

4.4 Sources should whenever possible be kept at a distance greater than 30 cm from the user, and should be pointed away from the human body.

5. Damage to, Loss of and Disposal of Sources

5.1 Retention of defective, obsolete or unnecessary sources is undesirable and positive steps shall be taken for the safe disposal of such sources. They shall either be returned to the suppliers and the Radiation Board notified; or be disposed of in a manner approved by the Radiation Board.

5.2 In the event of damage to, or loss of any sources, the following shall be notified immediately:

The Physicist on duty, Department of Health (Tel. : 7110 3382 call 1912)

The Occupational Health Officer, Department of Health (First Call Tel: 9689 0378; Second Call Tel: 9689 0450)

In all cases, the Secretary of Radiation Board shall be notified in writing within 48 hours.

6. The Degree of the Hazard

When due consideration is given to the limitation on the type of source, the activity of radioactive substances to be used in schools, and the time in any one year such sources will be used by any one teacher or student, the degree of hazard from exposure to ionizing radiation to both teachers and students is very small. However, it is essential that students appreciate the nature of the hazard and the degree of care considered necessary in the handling of radioactive substances.

Appendix 2

Procedures of Checking the Efficiency and Condition of the GM Tube and Scaler and Sample Results

Purpose : To check the efficiency and condition of the GM tube and scaler.

Apparatus : GM tube supported on its holder

Scaler

Source lifting tool

Support for source

Radioactive source (200 kBq Ra-226 or 200 kBq Sr-90)

Procedure :

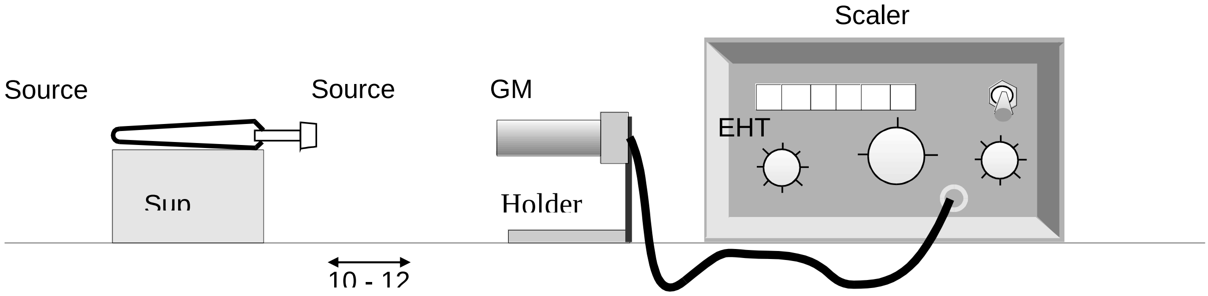


Figure 2.1

1. Set up the apparatus as shown in figure 2.1. The distance between the source and the GM tube should be about 10-12 cm. Make sure that the radioactive source is pointing along the axis of the GM tube.

2. Switch on the scaler and allow five minutes to warm up.

3. Gradually increase the E.H.T. supply from above 300 V to the point at which the scaler starts to register counts. Record the applied voltage and the number of counts in 100 s. Calculate the count-rate.

4. Increase the voltage in steps of 20 V (or a convenient value). Record the applied voltage and counts. Calculate the count-rate each time and continue up to about 500 V.

Results :

Source used : ____________________

Distance : ____________________ cm

1. Complete the following table :

Applied Voltage/V									
Counts in 100 s									
Count-rate /s^{-1}									

2. Plot a graph of count-rate against applied voltage. The graph should show a plateau (Figure 2.2) with threshold voltage V_T at about 400 V and plateau length V_L of about 100 V.

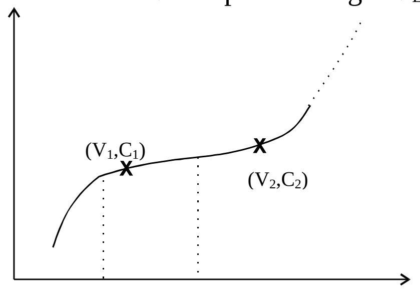


Figure 2.2

Above the threshold voltage, further increments in applied voltage cause only small increases in the count-rate and this region is called the Geiger plateau (plateau region).

3. The working voltage V_w may be taken as V_T + 50 V, i.e. about 450 V.

V_w = (____________ + 50) V = ________ V

4. The plateau slope may also be found by following the procedures:

Choose two points (V_1 , C_1) and (V_2 , C_2) on the plateau.

Applied voltage : V_1 = _____ V V_2 = _____ V

Corresponding Count-rate : C_1 = _____ s^{-1} C_2 = _____ s^{-1}

Mean count-rate : $C_0 = \frac{1}{2}(C_1 + C_2)$ = _______ s^{-1}

Plateau slope : $\%\ \text{slope} = \frac{C_2 - C_1}{V_2 - V_1} \times \frac{100\%}{C_0}$

= _______ % V^{-1}

Remark : I. The Plateau slope should not be more than 0.2 % V^{-1}

II. All values shown above are only characteristics of the GM tube, Mullard type ZP 1481 (MX 168). For other types of GM tubes, the relevant technical data should be referred.

Results :

SAMPLE

Source used : Sr 90 .
Distance : 11 cm

1. Complete the following table :

Applied Voltage/V	380	400	410	420	440	460	480	500	520
Counts in 100 s	7284	11258	12114	12430	12800	13254	13462	13813	14097
Count-rate/s	72.8	112.6	121.1	124.3	128.0	132.5	134.6	138.1	141.0

2. Plot a graph of count-rate against applied voltage. The graph should show a plateau (figure 2.2) with threshold voltage V_T at about 400 V and plateau length V_L of about 100 V.

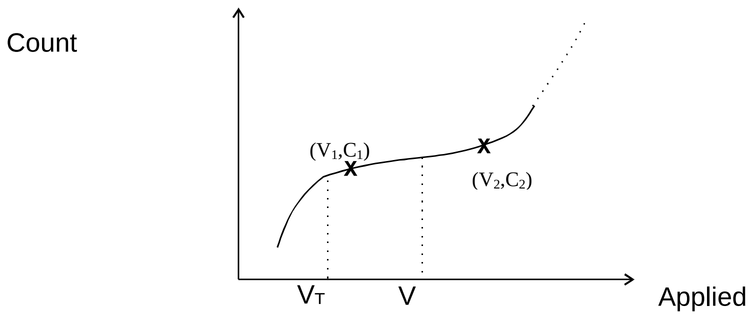


Figure 2.2

Above the threshold voltage, further increments in applied voltage cause only small increases in the count-rate and this region is called the Geiger plateau (plateau region).

3. The working voltage V_w may be taken as V_T + 50 V, i.e. about 450 V.

V_W = (410 + 50) V = 460 V

4. The plateau slope may also be found by following the procedures:

Choose two points (V_1 , C_1) and (V_2 , C_2) on the plateau.

Applied voltage : V_1 = 420 V V_2 = 520 V
Corresponding Count-rate : C_1 = 124.3 s^{-1} C_2 = 141.0 s^{-1}
Mean count-rate : $C_o = \frac{1}{2}(C_1 + C_2)$ = 132.65 s^{-1}
Plateau slope : $\% \text{ slope} = \frac{C_2 - C_1}{V_2 - V_1} \times \frac{100\%}{C_0}$
= 0.126 % V

Remark :

I. The Plateau slope should not be more than 0.2% V^{-1}

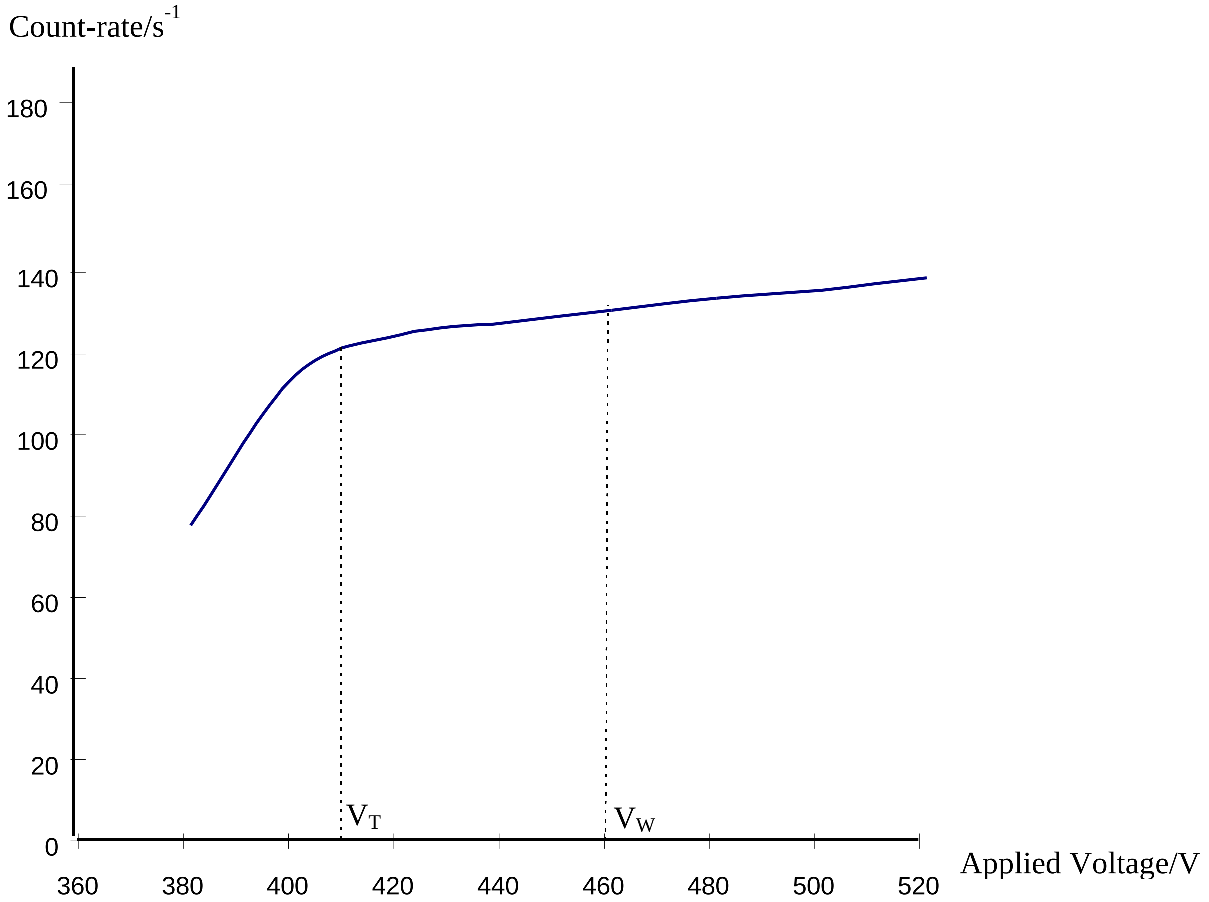
II. All values shown above are only characteristics of the GM tube, Mullard type ZP 1481 (MX 168). For other types of GM tubes, the relevant technical data should be referred.

SAMPLE

Graph of Count-rate against Applied voltage

source : Sr 90

distance : 11 cm



Procedures of Performing "Wipe Test" and Sample Results

Purpose : To check for leakage or surface contamination of sealed radioactive sources by the "Wipe Test".

Apparatus : GM tube supported on its holder

Scaler

Source lifting tool

Support for source

ALL sealed radioactive sources possessed by the school

Swab or tissue or cotton buds

Plastic Bags (food storage bags), at least four

Procedure :

1. Measurement of background count-rate

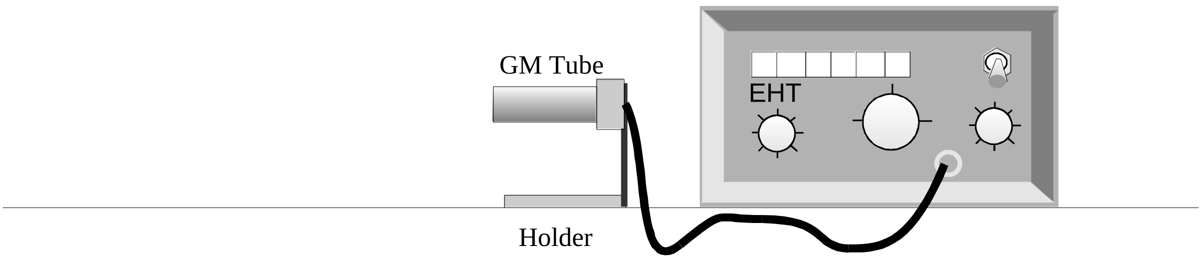


Figure 3.1

(a) Set up the apparatus as shown in Figure 3.1. Make sure that there is not any radioactive material in the vicinity of 1 m from the GM tube.

(b) Switch on the scaler and allow five minutes to warm up.

(c) Set the E.H.T. supply at the working voltage of the GM tube. Record the counts in a period of 10 minutes. Calculate the background count-rate.

2. Measurement of count-rate for the source

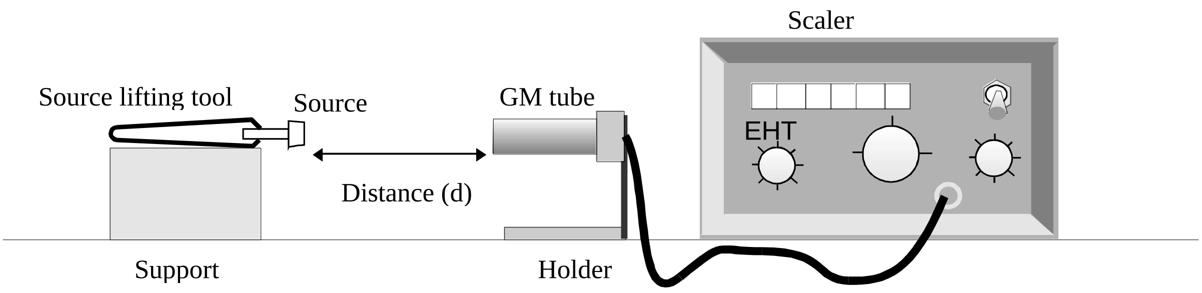


Figure 3.2

(a) Set up the apparatus as shown in Figure 3.2. Make sure that the source is pointing along the axis of the GM tube. The source should be placed at a distance (d) from the GM tube such that a count-rate of at least 200 s^{-1} is attained or such that the count-rate is as high as possible. For different sources, the following recommendations for the distance may be useful.

Source	Distance (d)	Remark
α source (e.g. Am-241 200 k/ 5 kBq)	As near as possible to the GM tube without touching the tube.	The plastic cap of the GM tube should be removed.
β source (e.g. Sr-90 350 k/ 200 kBq)	8 - 12 cm	-
β source (e.g. Sr-90 5 kBq)	1 - 3 cm	-
Source with β radiation (e.g. Ra-226 200 kBq)	8 - 12 cm	-
Source with γ radiation (e.g. Co-60 200 kBq)	1 - 3 cm	-

(b) With all conditions of the GM tube and scaler remain unchanged as in step 1. Record the number of counts in 100 s. Calculate the count-rate. Repeat for at least three times and determine the mean count-rate and the actual count-rate (= mean count-rate - background count-rate).

3. Measurement of count-rate for the wiping material

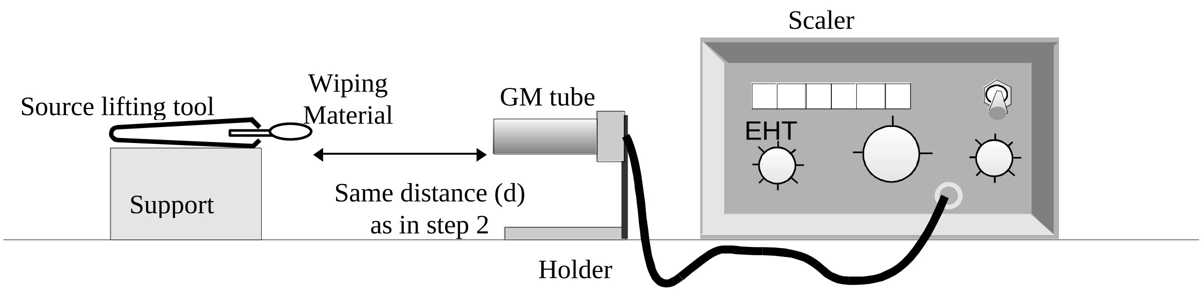


Figure 3.3

(a) Use a pair of tongs to grip a piece of cotton bud, swab or tissue, moistened with ethanol or water, wipe the entire external surface of the sealed source carefully and lightly. Avoid dropping any liquid onto the bench top and avoid scratching the source surface. Pay special attention when wiping α sources because of the fragile nature of their construction. Put the wiped source back to its storage box.

(b) Transfer the wiping material to the source lifting tool and set up the apparatus as shown in Figure 3.3. Make sure that the wiping material is at the same distance from the GM tube as in step 2 and the material is pointing along the axis of the GM tube. Also make sure that there is not any radioactive material in the vicinity of 1 m from the set-up.

(c) Record the number of counts in 10 minutes. Calculate the count-rate and determine the actual count-rate (= measured count-rate - background count-rate).

4. Put all wiping materials that are found to show no irregularities into double plastic bags which are to be sealed and disposed as usual garbage.

5. Any wiping material showing irregularities should be placed in separate double plastic bags labelled with the tested sources, date and time of testing, and estimated radioactivity of the wiping material. The bags should be sealed and stored in the storage cupboard for further action.

6. Update the "Sealed Radioactive Source Record".

7. Repeat steps 1 to 6 to check for ALL sealed radioactive sources possessed by the school.

Results :

1. Background count-rate

Counts in 10 minutes period = ____________

Background count rate = C_b = __________ s^{-1}

The background count-rate should be about 0.5 - 1.0 s^{-1}.

2. Count-rates for the sources and the wiping materials

Source								
Radioactivity /Bq								
Distanced /cm								
Counts in 100s for source								
Mean count-rate for source C_m /s^{-1}								
Actual count-rate for source ($C_s = C_m - C_b$) /s^{-1}								
Counts in 10 minutes for wiping material								
Count-rate for wiping material C_c /s^{-1}								
Actual count-rate for wiping material ($C_w = C_c - C_b$) /s^{-1}								

3. Activity of the wiping material

The activity of the wiping material may be estimated by assuming under the same experiment conditions, the actual count-rate is directly proportional to activity.

For : C_s = actual count-rate of the source

C_w = actual count-rate of the wiping material

A_s = activity of the source

A_w = activity of the wiping material

$$\frac{A_s}{A_w} = \frac{C_s}{C_w}$$

$$A_w = A_s \times \frac{C_w}{C_s}$$

Complete the following table :

Source								
Activity of source A_s /Bq								
Actual count-rate for source C_s /s^{-1}								
Actual count-rate for wiping material C_w /s^{-1}								
Activity of wiping material A_w /Bq								
Result of "Wipe Test"								

The acceptance limit is 200 Bq. Mark the source in the table with an asterisk "*" and label the storage box of the source that fails in the "Wipe Test".

Remarks

I. Owing to the random nature of radioactivity, the actual count-rate of the wiping material may be negative. In this case, the activity of which may be considered to be negligible.

II. If the "Wipe Test" is carried out in separate sessions, the background count-rate should be measured before each session.

III. As the half life of the Co-60 source is only 5.27 years, this should be taken into account when calculating the radioactivity in the "Wipe Test". The source may be considered to have a radioactivity of 200 kBq at the date of delivery. The radioactivity of the Co-60 source can be calculated using the formula below:

$$A_s = 200\, e^{-\lambda t} \text{ kBq}$$

$$\text{where} \quad \lambda = \frac{\ln 2}{5.27}$$

A_s = Activity of source
t = time in years since delivery of the source

IV. The purpose of performing "Wipe Test" is to check whether the radioactive sources are leaking. It is therefore not always necessary to find out the actual radioactivities on the wiping materials. In that case, a more straight forward approach may be adopted. This is done by counting the individual wiping material for a period of 10 min. After which the number of counts is compared with that from background. If the difference exceeds 3 standard deviation (at 1% significant level) of background counts, then the source is suspected to be leaking. The table below would be used in place of the table in paragraph (3) for the results.

Background counts (N) for 10 min . =

Standard deviation of background counts ($\sqrt{N}$) =

3 x (standard deviation) = $3\sqrt{N}$ =

Source wiped								
Counts in 10 min. for wiping material								
Actual counts (= Measured counts - background counts)								
Actual counts larger than 3 standard deviation								
Result of "Wipe Test"								

NOTE : In employing the method described on this page, the wiping materials need not be placed too far away and at various distances from the GM tube since comparisons with source activities are not necessary. In this case, all wiping materials can be placed at 0.1 - 0.5 cm from the detector such that detection sensitivity would be increased.

Results :

SAMPLE

1. Background count-rate

Counts in 10 minutes period = 405

Background count rate C_b = 0.675 s^{-1}

The background count-rate should be about 0.5 - 1.0 s^{-1} .

2. Count-rates for the sources and the wiping materials

Source	Ra-226	Am-241	Sr-90	Co-60	Sr-90	Am-241	Sr-90	Co-60
Radioactivity /Bq	200 k	200 k	200 k	200 k	350 k	5 k	5 k	200 k
Distance d /cm	10.5	0.1	8	1	6	0.1	2	1
Counts in 100s for source	23719	54543	22194	12601	23849	20093	7216	8943
	23513	55336	23098	12517	23767	19913	7288	9159
	23511	55093	21879	12502	23832	21485	7339	9053
Mean count-rate for source C_m /s^{-1}	235.8	548.9	223.9	125.4	238.2	205.0	72.8	90.5
Actual count-rate for source C_s ($= C_m - C_b$) /s^{-1}	235.1	549.2	223.2	124.7	237.5	204.3	72.1	89.8
Counts in 10 minutes for wiping material	395	390	402	437	387	374	388	386
Count-rate for wiping material C_c /s^{-1}	0.66	0.65	0.67	0.73	0.65	0.62	0.65	0.64
Actual countrate for wiping material ($C_w = C_c - C_b$) /s^{-1}	Negl	Negl	Negl	0.05	Negl	Negl	Negl	Negl

3. Activity of the wiping material

The activity of the wiping material may be estimated by assuming under the same experiment conditions, the actual count-rate is directly proportional to activity.

For : C_s = actual count-rate of the source

C_w = actual count-rate of the wiping material

A_s = activity of the source

A_w = activity of the wiping material

$$\frac{A_s}{A_w} = \frac{C_s}{C_w}$$

$$A_w = A_s \times \frac{C_w}{C_s}$$

Complete the following table :

Source	Ra-226	Am-241	Sr-90	Co-60	Sr-90	Am-241	Sr-90	Co-60
Activity of source A_s /Bq	200 k	200 k	200 k	200 k	350 k	5 k	5 k	200 k
Actual count-rate for source C_s /s^{-1}	235.1	549.2	223.2	124.7	237.5	204.3	72.1	89.8
Actual count-rate for wiping material C_w /s^{-1}	Negl	Negl	Negl	0.05	Negl	Negl	Negl	Negl
Activity of wiping material A_w /Bq	Negl	Negl	Negl	56.1	Negl	Negl	Negl	Negl
Result of "Wipe Test"	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

The acceptance limit is 200 Bq. Mark the source in the table with an asterisk "*" and label the storage box of the source that fails in the "Wipe Test".

Remarks

I. Owing to the random nature of radioactivity, the actual count-rate of the wiping material may be negative. In this case, the activity of which may be considered to be negligible.

II. If the "Wipe Test" is carried out in separate sessions, the background count-rate should be measured before each session.

IV. The purpose of performing "Wipe Tests" is to check whether the radioactive source are leaking. It is therefore not always necessary to find out the actual radioactivities on the wiping materials. In that case, a more straight forward approach may be adopted. This is done by counting the individual wiping material for a period of 10 min. After which the number of counts is compared with that from background. If the difference exceeds 3 standard deviation (at 1% significant level) of background counts, then the source is suspected to be leaking. The table below would be used in place of the table in paragraph 3 for the results.

Background counts (N) for 10 min. = 405

Standard deviation of background counts ($\sqrt{N}$) = 20.1

3 x (standard deviation) = $3\sqrt{N}$ = 60.3

Source wiped	Ra-226 200k	Am-241 200k	Sr-90 200k	Co-60 200k	Sr-90 350k	Am-241 5k	Sr-90 5k	Co-60 200k
Counts in 10 min. for wiping material	395	390	402	437	387	374	388	386
Actual counts (= Measured counts - background counts)	Negl	Negl	Negl	32	Negl	Negl	Negl	Negl
Actual counts larger than 3 standard deviation	No	No	No	No	No	No	No	No
Result of "Wipe Test"	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.

NOTE : In employing the method described on this page, the wiping materials need not be placed too far away or at specific distances from the GM tube since comparisons with source activities are not necessary. In this case, all wiping materials can be placed at 0.1 - 0.5 cm from the detector such that detection sensitivity would be increased.

Appendix 4

Record Form for Storage of Radioactive Sources and Samples

Sealed Radioactive Source Record		Quantity	Nuclide
Supplier	Type No.	Activity	On (date)
Location		Responsible Person	
		Name	Signature
Description of source			
Description of container			
Drawings of source and container			

<u>Routine Check</u> :

Date	Result of "Wipe Test"	Signature of Custodian	Remark

SAMPLE

Sealed Radioactive Source Record		**Quantity** 1	**Nuclide** Americium - 241
Supplier Hong Kong Scientific Co.	**Type No.** Philip Harris Q87215/7	**Activity** 200 kBq	**On (date)** 1 Jan. 2023
Location Cupboard B3, Preparation Room,Physics Laboratory.		**Responsible Person**	
		Name Mr. CHAN Tai-man	**Signature** TM Chan

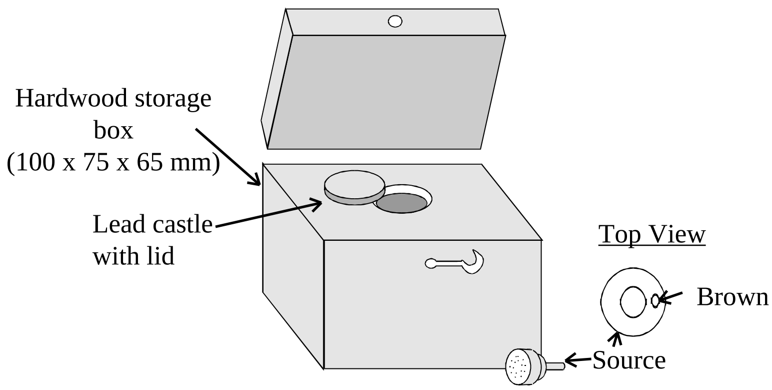
Description of source
Mainly an alpha emitter, may have some gamma emission but the highest energy is 60 keV

Energies :
α = 5.44, 5.48 MeV
γ = 0.026 - 0.060 MeV
Colour code : Brown

Half-life :
458 years

Description of container
Sealed source in metal mounted with 4 mm stem, supplied in lead castle envelope in wooden box.

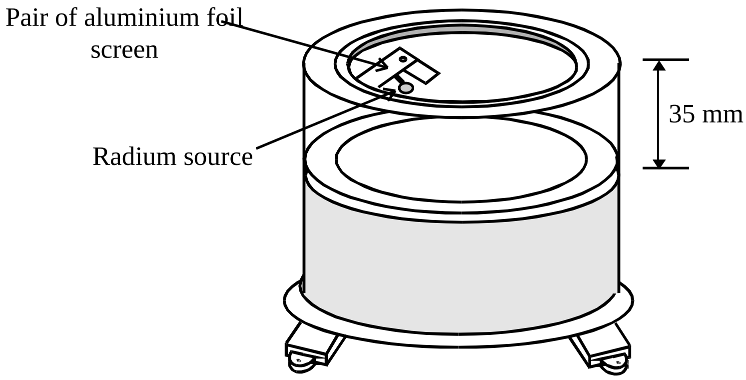
Drawings of source and container



Routine Check :

Date	Result of "Wipe Test"	Signature of Custodian	Remark

<table>
<tr><td colspan="2">Sealed Radioactive Source Record</td><td>Quantity 5</td><td>Nuclide Radium</td></tr>
<tr><td>Supplier
Hong Kong
Scientific Co.</td><td>Type No.
Philip Harris Q87600/9
Diffusion cloud chamber</td><td>Activity
< 750 Bq</td><td>On (date)
1 Jan. 2023</td></tr>
<tr><td colspan="2" rowspan="2">Location

Cupboard C2, Preparation Room, Physics Laboratory.</td><td colspan="2">Responsible Person</td></tr>
<tr><td>Name
Mr. CHAN Tai-man</td><td>Signature
T.M.Chan</td></tr>
<tr><td colspan="4">Description of source
The weak radioactive source (radium) gives mainly alpha and beta radiations.</td></tr>
<tr><td colspan="4">Description of container
The source is mounted on the inside of the diffusion cloud chamber together with a pair of aluminium foil screen, which is approximately 0.025 mm and 0.18 mm thick respectively.</td></tr>
<tr><td colspan="4">Drawings of source and container


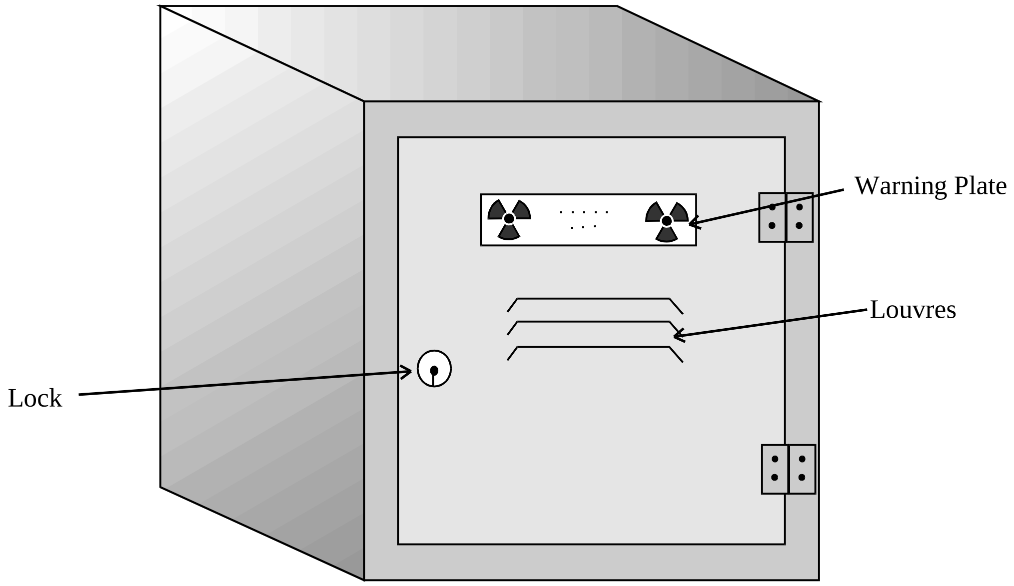
Overall dimension : 105 mm diameter
90 mm height</td></tr>
</table>

Appendix 5

Specifications for Storage Cupboard

Storage cupboard

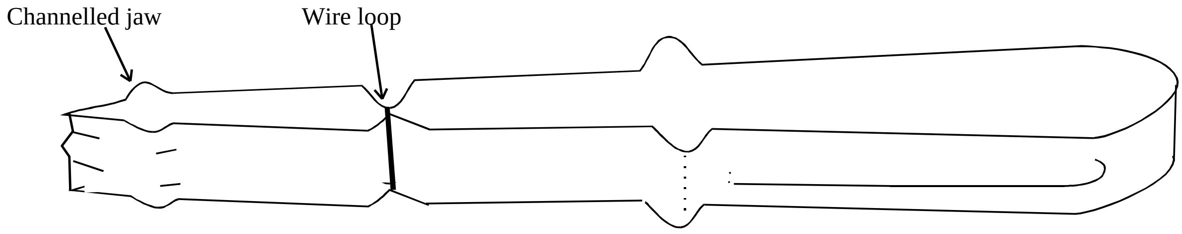
A stoutly built enamelled sheet-steel cupboard having a louvred, lockable door bearing an appropriate warning plate. The rear wall of the cupboard carries two narrow steel shelves. A rectangular plastic tray is provided so that any spillages are contained and can be washed away easily. Dimensions 380 mm x 380 mm x 380 mm.



Specifications for the Radioactive Source Lifting Tool

Radioactive source lifting tool

For lifting sources and supporting them during use. Plated phosphor-bronze spring holder with jaws channelled longitudinally and transversely. Overall length 150 mm.



Appendix 7

輻射管理局

RADIATION BOARD

申請豁免存放放射性物質牌照在學校使用放射源(註釋 1)作教學用途

APPLICATION FOR EXEMPTION FROM REQUIRING RADIOACTIVE SUBSTANCES LICENCE

Use of Radioactive Sources[1] for Teaching Purposes in Schools

1. 學校／學院名稱：
Name of School/College： ______________________

地址：
Address : ______________________

電話號碼： Telephone No.: ________ 傳真號碼： Fax No.: ________ 電郵地址： E-mail Add.: ________

2. 指定為放射源保管人的教師(註釋 2)姓名及學歷。
Name and qualification of the teacher designated as the source custodian [2] .

姓名 Name (Surname first)	取得之學位及主修科目 Degree(s) Obtained and Major Subjects	頒授學位之機構 Awarding Institution	年份 Year

如上述教師已擁有物理學位，則不用填寫此部份，請到第三部份繼續填寫。
If the above teacher has a degree majoring in physics, skip the following part and continue with part 3.

上述教師是否擁有最少兩年教授高中物理的經驗(例如：中四至中六)?
Does the above teacher have at least 2 years experience in teaching higher form physics (e.g. Secondary 4-6)?

是 Yes ☐ 否 No ☐

上述教師是否曾修畢由輻射管理局認可之輻射防護課程?
Has the above teacher attended and completed any radiation protection course recognised by the Radiation Board?

是 Yes ☐ 否 No ☐ 如是，請說明課程名稱及主辦機構名稱
If Yes, please state the course title and the organising body

____

3. 本校所用放射源(註釋 3)之資料：
Details of radioactive sources [3] to be used in the school:

已管有 Already in Possession

供應商 Supplier	製造商／目錄編號 Manufacturer/Catalogue Number	放射源 Source	每個放射源的活度 Activity per source	放射源的數目 No. of source

擬購置 To Be Acquired

供應商 Supplier	製造商／目錄編號 Manufacturer/Catalogue Number	放射源 Source	每個放射源的活度 Activity per source	放射源的數目 No. of source

*請將不適用者刪去 *Delete as appropriate

4. 本校已*購置／訂購之監察器(註釋 4)為：
The type of monitoring instrument (4) acquired/already put on firm order for purchase* :

____

本人擬申請於輻射條例下豁免放射性物質牌照，茲證實上述放射源均用作教學用途，並遵守「在學校使用放射源作教學用途之守則」。
I hereby apply for exemption from requiring radioactive substances licence under the Radiation Ordinance. I declare that the above source(s) is/are* for teaching purposes and that the instruction in the "Code of Practice on the Use of Sealed Radioactive Sources for Teaching Purposes in Schools" will be complied with.

校長署名：
Principal Signed : ____________________

學校印鑑：
School Chop : ____________________

校長姓名：
Principal Name: ____________________

日期：
Date : ____________________

註釋
Guidance Notes

(1) 根據香港法例第303章輻射條例，放射性物質指由任何天然或人工的放射性化學元素組成的任何物質，或包含該等元素的任何物質，而其放射性比度，以每克物質計算，超逾75貝克勒爾的源放射性化學元素。
According to the Radiation Ordinance, Cap.303, Laws of Hong Kong, "radioactive substance" means any substance which consists of or contains any radioactive chemical element whether natural or artificial and whose specific activity exceeds 75 becquerels of parent radioactive chemical element per gram of substance.

(2) 作為放射源保管人的教師應負責督導校內放射性物質之使用。該教師應持有認可的學位，並符合以下任何一項條件：
The source custodian shall be responsible for the use of radioactive substances within the school. He/She should have a recognised degree and satisfy either one of the following conditions :
- (i) 主修物理
  Physics major
- (ii) 擁有最少兩年教授高中物理的經驗(中四至中六)
  At least two years teaching experience in higher form Physics (Secondary 4-6)
- (iii) 持有輻射管理局認可之輻射防護證書
  Certificate on radiation protection recognised by the Radiation Board

(3) 存放於學校實驗室的密封放射源的數量及放射性活度，應維持在實際所需的最低水平。在任何情況下，實驗室所存放的放射源種類、數量及放射性活度不得超出下表所列的豁免上限：
The quantity and the activity of the sealed sources in a school laboratory should be kept at the minimum practicable levels and shall in all cases be no greater than the following exemption limit.

密封放射源 Sealed sources	數量 Quantity
鋂-241、 鈷-60、鐳-226、鍶-90 Americium-241, Cobalt-60, Radium-226, Strontium-90	◆ 每類不超過兩個放射源 No more than two sources of each type ◆ 每個放射源的放射性活度不超逾200kBq No more than 200kBq for each source
放射強度少於750Bq而用於擴散雲室的不溶性鐳-226放射源 Insoluble radium-226 source of activity less than 750Bq to be used with diffusion cloud chamber	◆ 不超過10個放射源 No more than 10 sources ◆ 10個放射源的總放射性活度不超逾7.5kBq No more than 7.5kBq in 10 sources

學校可參考教育局的科學實驗室安全手冊(2013)。
Schools may refer to the Handbook on Safety in Science Laboratory (2013) issued by the Education Bureau for reference.

(4) 該儀器可以是一個能夠量度β及γ-輻射的便攜式監察器，例如一個包括一支薄端窗之蓋革-彌勒管的系統。惟用於擴散雲室而放射性活度少於750Bq的鐳-226放射源，則無需用監察器。
The instrument may be a portable monitoring instrument capable of measuring beta and gamma radiation, for example, a system with a Geiger-Muller thin end window tube. However, for radium-226 source of activity less than 750Bq to be used with diffusion cloud chamber, monitoring instrument is not required.

(5) 填妥表格後，請交回香港西灣河太康街28號西灣河健康中心3樓衞生署放射衞生部輻射管理局秘書。
On completion, the form should be sent to the Secretary of the Radiation Board, Radiation Health Unit, Department of Health, 3/F., Sai Wan Ho Health Centre, 28 Tai Hong Street, Sai Wan Ho, Hong Kong.

*請將不適用者刪去 *Delete as appropriate