University of Windsor Radiation Safety Bulletin
Contamination Monitoring

The University of Windsor's Radiation Safety Polices and Canadian Nuclear Safety Commission's (CNSC) consolidated licence stipulates that all licensed radioisotope laboratories develop and utilize a laboratory specific radioactivity contamination monitoring program. As such, all radioisotope facilities must be monitored for contamination and detailed records maintained supporting the contamination detection program.

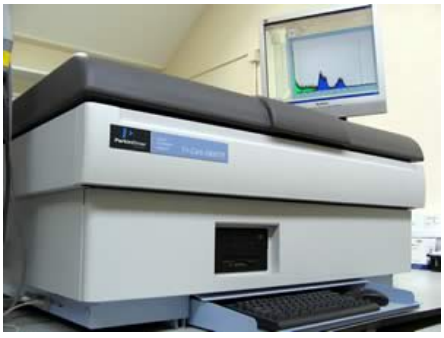
Methods of Measurement:

Direct: Measurements are taken using a portable radiation detection instrument to detect both fixed and removable contamination.

Steps:

1. Monitor the locations listed on your plan by slowly moving the detector face toward the surface being monitoring.
2. If contamination is detected, stop and obtain a measurement. Record the reading (Bq).
3. Determine if the reading is above the licence criteria. If so, clean the area.
4. Re-monitor the location for each cleaned area and record the final measurement (Bq) after decontamination.

Indirect: Measurements are indirectly taken by measuring the amount of radiation which is transferred to a disposable wipe.



Steps:

1. Using uniform and constant pressure, wipe approximately 100cm^2 of each area on your plan with a filter paper, wipe, or cotton swab which is lightly moistened with alcohol or water.
2. Count the wipes using a liquid scintillation counter or using a contamination monitor if the wipe is equal or less than the area of the detector.
3. Determine if the readings observed are above the licence criteria. If so, clean the area.
4. Re-monitor the location for each cleaned area and record the final measurement (Bq) after decontamination.

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Location, Location, Location:

The locations which are to be monitored must be numbered on a plan of the radioisotope work area. These surfaces should include working surfaces (i.e. benches, counter tops, and fume hoods) along with non-working surfaces (i.e. instruments, door handles, and phones). In addition, a few random locations should also be included.

Frequency:

All radioisotope laboratories **actively using radioactive materials** must be monitored at least on a weekly basis to detect surface contamination.

If no radioisotopes have been used since the previous survey, permit holders are not required to conduct contamination monitoring until the next usage. However, it should be recorded in the "Radioisotope Inventory Record" log book that no radioactive work has been conducted.

Decontamination:

Any area that is found to have non-fixed contamination exceeding the regulatory criteria must be cleaned and re-monitored. Please refer to your University of Windsor Radioisotope Permit for more information or visit our website (www.uwindsor.ca/ccc).

Radionuclide	EQ (MBq)	Wipes Controlled area (Bq/cm^2)	Wipes Public area (Bq/cm^2)
C-14	100	300	30
H-3	1000	300	30
P-32	0.01	300	30
S-35	100	300	30
Please see permit for specific information			

Monitoring Records:

The results of all wipe tests must be kept within the log-book for up-to three years. The "Radioisotope Inventory Record" should be kept within the licensed area and available for inspection by either the RSO or CNSC Inspectors. Please see appendix for an example of a monitoring record sheet.

Calculations:

Formula	
Removable activity (Bq/cm2):	**N - NB / E x 60 x A x (F)**

Value	Description
N	Total count rate in counts per minute (CPM) measured directly or on the wipe
NB	Normal background count rate (CPM) from the survey insturment or ont the blank
E	Instrument efficiency factor (%) for the radioisotope being measured
60	Sec/min
A	Area wiped (not to exceed 100 cm2) or the area of the detector
F	Collection factor of the wipe (assume 10%)

Detector Efficiencies:

Perkin-Elmer Tri-Carb© 2900 liquid scintillation analyzer

Isotope	Efficiency
C-14	95%
H-3	58%
P-32	98%
S-35	95%

Example Calculation:

Formula	
Removable activity (Bq/cm2):	**N - NB / E x 60 x A x (F)**

Liquid Scintiallation Calculations	
N	157
NB	90
E	98%
Isotope: P32	
60	60
A	100
F	10%

Removable activity (Bq/cm2):	0.113945578

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University of Windsor Radiation Safety Program - Laboratory Survey Log

Date	Time	Surveyor's Name	Isotope Used	Survey Type		Results (Bq/cm2)	Survey Meter User: Mfg., Model, Serial No, & Probe Type
				Personal	Work Area		

* For more information, please refer to the University of Windsor's Radiation Safety Program website (www.uwindsor.ca/radiation)

RADIOISOTOPE SAFETY
Monitoring for Radioactive Contamination

INFO-0545

1. INTRODUCTION

This document provides general guidance for monitoring and controlling radioactive contamination, and relating the monitoring results to the AECB radioisotope licence criteria. This document pertains primarily to laboratories, but also applies to the control of radioactive contamination in other locations. The document also provides guidance on contamination monitoring instrument selection.

Each AECB radioisotope licence authorising the use of open source radioactive material contains a condition which states the regulatory criteria pertaining to radioactive contamination. This licence condition is stated in Annex 1.

The specified contamination criteria must be applied to all areas where radioisotopes are used. Notwithstanding these limits, licensees should maintain levels of radioactive contamination as low as reasonably achievable (ALARA).

2. ELEMENTS OF A CONTAMINATION MONITORING PROGRAM

2.1 Method of Measurement

Radioactive contamination may be measured directly or indirectly. Direct measurement means the use of portable radiation detection instruments to detect both fixed and removable contamination. Direct measurement may be used when background radiation levels are negligible compared to licence criteria. Indirect measurement only detects removable contamination by means of wipe tests.

2.2 Instrument Selection

The ability of various radiation detection instruments to detect radioisotopes of interest will vary with the instrument and manufacturer. Guidance on the selection of instruments is given in a table in Annex 2. For specific information on a particular make or model, contact the manufacturer.

2.3 Locations of Measurement

The locations that are to be monitored should be numbered on a plan of the radioisotope work area. These locations should include working surfaces, such as benches, countertops, fume hoods, etc., storage areas, and non-working surfaces such as floors, instruments and equipment, door handles, light switches, sink taps and telephone receivers. Several random locations should also be monitored. Too rigid a set of locations may overlook problem areas.

2.4 Instrument Checks and Calibration

Non-portable instruments used for counting wipes, such as liquid scintillation counters, well-crystal type gamma counters, gas-flow proportional counters, semiconductor gamma spectrometers and gamma cameras, should be routinely serviced according to the manufacturer's instructions. Keep a record of the service information and dates.

Before monitoring for contamination, portable instruments should be given operational checks as specified by the manufacturer (i.e. battery check, high-voltage check, response check, etc.) and the background radiation level should be measured. Record the operational checks and background measurement. Similarly, non-portable instruments used to count wipes should count and record a blank and standard with each set of wipes.

Instruments that are not operating within the parameters of the operational checks or which show anomalous background, blank or standard measurements, should not be used until their proper operation can be verified.

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Canada

2.5 Frequency of Monitoring

Contamination monitoring frequencies must conform to the requirements indicated on the appropriate AECB Laboratory Rules Poster, or in a radioisotope licence condition.

When radioactive material is not used for a prolonged period of time, contamination monitoring is not required, but such a period should be identified in the records.

2.6 Decontamination

Any area that is found to have non-fixed contamination exceeding the regulatory criteria must be cleaned and remonitored. If the area cannot be cleaned to meet the criteria, the contaminated surface must be sealed, removed or shielded until the criteria are met.

NOTE: For short-lived radionuclides, the room or area may be posted and secured until the radioisotope decays.

2.7 Monitoring Records

Contamination monitoring records must be kept for three years and must be available for inspection by AECB staff. These records should include:

a) date of measurement
b) make and model of the instrument
c) monitoring locations
d) contamination monitoring results in Bq/cm² (before and after decontamination)
e) for portable instruments, the results of operational checks and background measurements
f) for non-portable instruments, blank and standard measurement results

Instrument calibration data should be recorded and updated as necessary.

3. DIRECT MEASUREMENT OF CONTAMINATION USING A PORTABLE METER

Depending upon the detector and the radioisotopes, direct measurement is often convenient for monitoring large areas. Direct measurement instrument readings include both fixed and non-fixed contamination. Thus a reading which satisfies the licence criteria gives a conservative estimate of non-fixed contamination.

a) Monitor the locations marked on the plan of the working area by slowly passing the detector over each area.
b) Keep the detector face towards the surface being monitored and keep the distance between the detector and surface as small as possible without touching (and possibly contaminating) the detector.
c) If contamination is detected, stop and obtain a measurement. Clean the area until the instrument measurement is below the licence criteria. A reading in excess of licence criteria after repeated cleaning is an indication of fixed contamination or a high radiation background.
d) Identify and mark the contaminated area on the plan.
e) Record the highest measurement for each area and the final measurement after decontamination.

4. INDIRECT MEASUREMENT OF CONTAMINATION WITH WIPES

a) Wipe each of the locations shown on the plan of the working area with a filter paper, wipe or cotton swab lightly moistened with alcohol or water. Use one numbered wipe per location. (Note 1)
b) Wipe an area of 100 cm². Using uniform and constant pressure, ensure the entire area is wiped.
c) If necessary, carefully dry the wipe to prevent loss of activity. (Note 2)
d) Count the wipes in a low-background area and record all results.
e) If the wipes are to be counted on a contamination meter, the wipe should be smaller than or equal to the sensitive area of the detector.
f) Clean any contaminated areas and remonitor. Record results before and after decontamination.

NOTES:

1) One "screening" wipe can be used to monitor several locations. If contamination is found, the contaminated area must be identified and decontaminated.
2) Since the contamination may be absorbed into the wipe material, the use of a wetting agent may lead to a significant underestimate of alpha and low-energy beta contamination with some counting methods.

5. RELATING MEASUREMENT READINGS TO REGULATORY CRITERIA

The readings from contamination meters and non-portable instruments can be related to regulatory criteria if the efficiency of the instrument for a specific radioisotope is known.

Instrument efficiencies for specific radioisotopes can be obtained from the manufacturer or determined using an appropriate standard of known activity (For a description of instrument efficiency, see Annex III).

For mixtures of radioisotopes, do all calculations using the radioisotope for which the instrument has the lowest detection efficiency.

Using the following equation, calculate the measurement results in Bq/cm²

$$\text{Removable Activity} = \frac{N - NB}{E \times 60 \times A \times (F)}$$

WHERE:

- N = is the total count rate in counts per minute (CPM) measured directly or on the wipe
- NB = is the normal background count rate (in CPM) from the survey instrument or on the blank
- E = is the instrument efficiency factor (expressed as a decimal, i.e. for 26% efficiency, E=0.26) for the radioisotope being measured (consult the manufacturer or determine using a radioactive source with a known amount of activity in a counting geometry similar to that used when surveying for contamination) (see Annex 3)
- 60 = sec/min
- A = area wiped (not to exceed 100 cm²) or area of the detector in cm² (for direct measurement)
- F = is the collection factor for the wipe (used ONLY when calculating indirect wipe monitoring results)

If F is not determined experimentally, a value of F = 0.1 (i.e. 10%) shall be used.

6. INSTRUMENT SENSITIVITY

Portable contamination monitoring instruments must be capable of making reproducible measurements at the licence criteria limits. A minimum detection limit is approximately twice the background measurement.

7. FURTHER INFORMATION

For further information about the implementation of this guide, contact the AECB at the following address:

Atomic Energy Control Board
Radioisotope and Transportation Division
P.O. Box 1046
Ottawa, Ontario
K1P 5S9

Telephone: (613) 995-1388
Facsimile: (613) 995-5086

AECB Radioisotope Licence criteria for radioactive contamination:

The licensee shall ensure that:

a) on all normally accessible working surfaces in any location where a radioactive prescribed substance is used or stored, non-fixed contamination does not exceed 0.5 becquerel per square centimetre of alpha activity or 5 becquerels per square centimetre of beta or gamma activity, averaged over an area not exceeding 100 square centimetres;
b) on all other surfaces, and prior to decommissioning any location where a radioactive substance has been used or stored, non-fixed contamination does not exceed 0.05 becquerel per square centimetre of alpha activity or 0.5 becquerel per square centimetre of beta or gamma activity, averaged over an area not exceeding 100 square centimetres;
c) the dose rate due to fixed contamination does not exceed 0.5 microsievert per hour at 0.5 metre from any surface; and,
d) records of all contamination measurements shall be maintained for at least three years.

SELECTION OF CONTAMINATION MONITORING INSTRUMENTS

The following is a general list of the various types of contamination monitoring instruments for some commonly used radioisotopes. Please consult the manufacturer for the exact specification of the instrument your are interested in.

HAND-HELD CONTAMINATION MONITORING INSTRUMENT	
Type of Instrument	**Code**
Thin-window G-M detector	1
Ion chamber with beta window	2
Gas-filled proportional detector	3
Thin-layer sodium iodide scintillation detector	4
Thick-crystal sodium iodine scintillation detector	5
Organic crystal/plastic scintillation detector	6
Zinc sulphide scintillation detector	7

NON-PORTABLE MONITORING INSTRUMENTS (WIPE COUNTERS)	
Type of Instrument	**Code**
Gas-Flow proportional counter	A
Liquid scintillation counter	B
Well-crystal sodium iodide counter	C
Semiconductor gamma spectrometers	D

COMMON RADIOISOTOPES AND SUGGESTED MONITORING INSTRUMENT SELECTION					
Radioisotope	**Half-Life**	**Principal Emission**	**Energy (keV)**	**Hand-Held Instruments**	**Non-Portable Instruments**
H-3	12 years	beta	5.7	6	B
C-14	5730 years	beta	49	1 2 3 6	A B
P-32	14 days	beta	695	1 2 3 6	A B
S-35	83 days	beta	49	1 2 3 6	A B
Ca-45	163 days	beta	77	1 2 3 6	A B
Cr-51	28 days	photon	320 (10%)	3 6	B C D
Mn-54	312 days	photon	835 (100%)	2 3 6	B C D
Fe-55	3 years	Electron Capture	5.9 (25%)	6	B C D
Co-57	272 days	photon	122 (86%)	2 3 4 5 6	B C D
Co-60	5 years	beta	606	1 2 3 5 6	A B C D
Ni-63	92 years	beta	17	2 3 6	A B
Ga-67	3 days	photon	93 (36%)	2 3 4 5 6	A B C D
Rb-86	19 days	beta	709	1 2 3 6	A B C D
Sr-90	28 years	beta	196	1 2 3 6	A B
Tc-99m	6 hours	photon	141 (89%)	2 3 4 5 6	A B C D
In-111	3 days	photon	245 (94%)	2 3 4 5 6	A B C D
I-125	60 days	photon	35 (6.5%)	2 4 6	B C D
I-131	8 days	beta	182	1 2 3 4 5 6	A B C D
Ba-133	11 years	photon	356 (60%)	1 2 3 4 5 6	A B C D
Cs-137	30 years	beta	157	1 2 3 5 6	A B C D
Ir-192	74 days	beta	180	1 2 3 4 5 6	A B C D
Tl-201	3 days	photon	167 (10%)	2 3 4 5 6	A B C D
Pb-210	22 years	beta	6.5	1 2 3 4 5 6	A B C D
Ra-226	1600 years	alpha	4780	1 2 3 4 5 6 7	A B C D

NOTE:

a) The principal energy quoted for beta emitters is the average beta energy.

b) The (%) beside the gamma emitters is the percent abundance for that energy.

c) Certain radioisotopes, such as Po-210 and Ra-226, are part of a decay chain and can be detected by measuring for their decay products. Ra-226 plus its daughters is an alpha, beta and gamma emitter and can be efficiently detected using a thin-window geiger detector, a well-crystal sodium iodide counter or a liquid scintillation detector.

d) Some hand-held instruments may also be used to screen wipes if used in a low-background area.

DETECTOR EFFICIENCY

The detector efficiency depends upon:

- the type of detector (GM, NaI Scintillation, Plastic Scintillation, Proportional)
- the detector size and shape (larger areas and volumes are more sensitive)
- the distance from the detector to the radioactive material
- the radioisotope and type of radiation measured (alpha, beta and gamma radiations and their energies)
- the backscatter of radiation toward the detector (the denser the surface, the more scattering)
- the absorbtion of radiation before it reaches the detector (by air and by the detector covering)

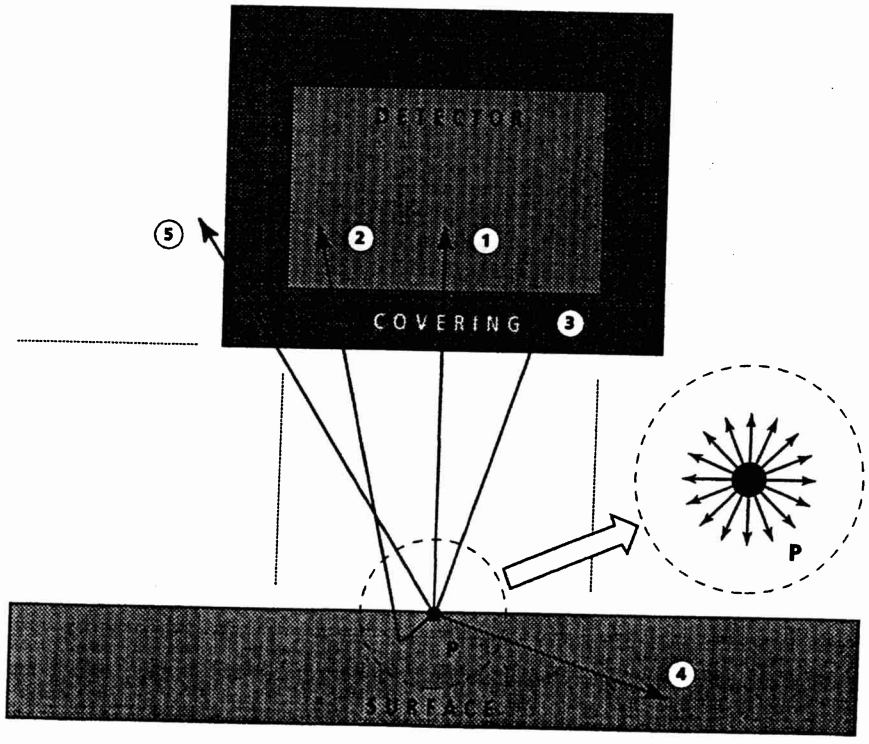
The factors affecting the efficiency are shown in the diagram below.

The detector efficiency can be found by:

1. Counting a standard source of known activity with your detector.

$$\text{efficiency} = \frac{\text{(detector count rate - background count rate)}}{\text{known activity of standard source}}$$

2. Asking the manufacturer about the efficiency of the detector for your specific radioisotope(s).



(1) Some radiation goes directly from the radioactive material **P**, into the detector.
(2) Some radiation will backscatter off the surface, into the detector.
(3) Some radiation is absorbed by the detector covering.
(4) Most radiation doesn't even get detected.
(5) If the detector was closer, this radiation would be detected.