

Dalhousie University Radiation Safety

Conducting Contamination Surveys in Nuclear Substance Laboratories

Introduction:

The goal of any radiation safety program is to keep the radiation dose to individuals and work place contamination levels *As Low As Reasonably Achievable (ALARA)*. The contamination survey provides a means for workers to assess the care with which radioactive materials are used as well as to document compliance with regulatory requirements. Hands, clothing and work areas *must* be monitored by an appropriate survey method at least as often as required by the CNSC. At Dalhousie we require that you do a direct survey with an appropriate survey meter on a daily basis when using ^{32}P or a gamma (γ) emitter. Wipe tests (indirect survey) must be performed on a weekly basis for any nuclear substance. *Records of these surveys must be maintained, up to date, and available for inspection at any time. Records of non-use periods must also be maintained.* These records are to be maintained in the yellow binder provided by the Radiation Safety Office.

Definitions:

ALARA	acronym for <i>As Low As Reasonably Achievable</i> - making every effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account technology, the economics of improvements in relation to benefits to the public health and safety, and other socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.
Background	ionizing radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays, and natural radioactivity is always present.
Becquerel	the international (SI) unit of radioactivity in which the number of disintegrations is equal to one disintegration per second.
Calibration	determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors. The check or correction of the accuracy of a measuring instrument is done to assure proper operational characteristics.

Contamination	deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful
Contamination	(fixed) - contamination which cannot be removed by wiping or cleaning the surface it is on
Contamination	(loose) - contamination which can be removed by wiping or cleaning the surface it is on
Decontamination	the reduction or removal of contaminating radioactive material from a structure, area, object or person. Decontamination may be accomplished by 1) treating the surface to remove or decrease contamination; 2) letting the material stand so that radioactivity is decreased as a result of natural decay; 3) covering the contamination to shield or attenuate the radiation emitted
Direct survey	measure both fixed and loose contamination and is performed by slowly moving a portable survey instrument over the surface you wish to monitor.
Efficiency	a measure of the probability that a count will be recorded when radiation is incident on a detector
GM counter	Geiger-Mueller - a radiation detection and measuring device consisting of a gas filled tube containing electrodes, between which there is electrical voltage but no current flowing. When ionizing radiation passes through the tube, a short intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted
Monitoring	the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses
Indirect survey	wipe test - measures only removable contamination and is performed by wiping a surface with an absorbent material and counting the wipe with an appropriate radiation counter (eg LS counter) to determine the amount of radioactive material that was removed
Scintillation counter	a counter in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.

Regulatory Requirements:

Dalhousie University *Radiation Safety Program* requires:

- a) Monitor laboratory for loose contamination at least weekly.
- b) Maintain record of results and decontaminate if necessary.
- c) Maintain records of non-use periods

CNSC's *Nuclear Substances and Radiation Devices Licence* condition 16 states

The licensee shall ensure that for all nuclear substances listed in the licence application guide.....

- a) *non-fixed contamination in all areas, rooms or enclosures where unsealed nuclear substances are used or stored does not exceed:*
 - i) *3 becquerels per square centimetre for all Class A radionuclides*
 - ii) *30 becquerels per square centimetre for all Class B radionuclides; or*
 - iii) *300 becquerels per square centimetre for all Class C radionuclides averaged over an area not exceeding 100 square centimetres; and*
- b) *non-fixed contamination in all other areas does not exceed:*
 - i) *0.3 becquerels per square centimetre for all Class A radionuclides*
 - ii) *3 becquerels per square centimetre for all Class B radionuclides; or*
 - iii) *30 becquerels per square centimetre for all Class C radionuclides; averaged over an area not exceeding 100 square centimetres*

Licence condition 18 states

The licensee shall..... ensure that the dose rate at any occupied location outside the storage area, room or enclosure resulting from the substances or devices in storage does not exceed 2.5 microsieverts/hour

Notwithstanding these limits which are based on possible health risks, licensees shall maintain levels of radioactive contamination *ALARA* as defined in Dalhousie University's *ALARA Policy*.

INDIRECT SURVEY (WIPE TEST)



The indirect survey or wipe test is the most sensitive method for determining the amount of removable contamination. It is the only method for determining whether contamination is removable or fixed.

Procedure:

1. Prepare a floor plan of the lab.
2. Mark locations to be tested which at a minimum must include:
 - i) workbench
 - ii) floor near workbench
 - iii) fume hoods (including sash, ledge, work surface)
 - iv) floor near fume hoods
 - v) liquid disposal sink
 - vi) floor near sink
 - vii) storage refrigerator and/or freezer
 - viii) floor near refrigerator/freezer
 - ix) equipment used
 - x) telephone receivers
 - xi) door knobs
 - xii) computer key boards
3. Using a Q-Tip swab or a filter paper disk moistened with a suitable solvent (water or alcohol) wipe a representative area (100 cm²). **Use only one wipe per location.**
4. Prepare a control sample using a clean swab or filter. The control provides the background count rate.
5. Allow the wipes to air dry.
6. Prepare samples for counting by placing the disk or swab in a LS counting vial.. If you are counting a filter paper disk place the wiped side up on the bottom of the vial.
7. Add appropriate counting cocktail.

8. Mark cap with correct wipe identification and re-cap vial.
9. Count using a counting window appropriate for the radionuclide you wish to survey for.
10. Contact the RSO for instructions for counting wipes for gamma emitting radionuclides.
11. Record results.

Remember that the wipe efficiency is only about 10%.

Tips:

- ' factors such as chemiluminescence and static can cause false positive results
- ' a moist filter or Q-tip improves the survey sensitivity enabling more activity to be transferred
- ' using a large filter or a mini vial may cause the filter to either fold in on itself or attach to the side of the vial, thus reducing the counting efficiency particularly for lower energy beta emitters.
- ' LS counting efficiencies are normally provided by the counter manufacturer

Weekly Contamination Survey

Principal Investigator: _____

Permit #: _____

Room #: _____

Week Of	Nuclear Substance Used	Nuclear Substance Not Used	Week Of	Nuclear Substance Used	Nuclear Substance Not Used
1			27		
2			28		
3			29		
4			30		
5			31		
6			32		
7			33		
8			34		
9			35		
10			36		
11			37		
12			38		
13			39		
14			40		
15			41		
16			42		
17			43		
18			44		
19			45		
20			46		
21			47		
22			48		
23			49		
24			50		
25			51		
26			52		

WEEKLY LABORATORY WIPE TEST RESULTS

Principal Investigator: _____ **Permit #:** _____

Room #: _____

Type Of Counter Used: _____ **LSC**

_____ **Other (specify)**

Nuclear Substance Used: _____ **Background Count:** _____

Date: (d/m/y): _____ **Surveyor's Initials:** _____

Please attach printer printout below:

CONVERSION FACTORS WIPE TEST CONTAMINATION MONITORING

To obtain the surface contamination level in Bq/cm² multiply the wipe test sample count rate by a suitable conversion factor derived from the following table. The table of conversion factors will serve for any gamma or liquid scintillation well counter.

Using The Conversion Table

- U Area of wipe is assumed to be 100 cm² (*if the area is greater or smaller than 100 cm², the conversion table is no longer valid*)
- U Efficiency of wipe in removing loose surface contamination is assumed to be 10 %
- U Units of disintegration rate are assumed to be in dpm
- U Determine the counting efficiency of the gamma or liquid scintillation counter for the radioisotope being monitored
- U Multiply the net counts per minute (sample counts minus background counts) by the conversion factor to obtain the results in Bq/cm²

Wipe Test Conversion Factors and Net Count Rates for 2 Selected Contamination Levels

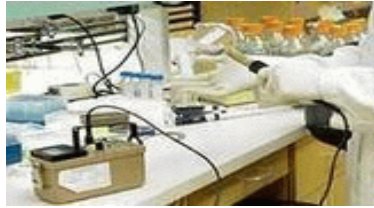
Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.01	0.16667	3	30
0.02	0.83333	6	60
0.03	0.05556	9	90
0.04	0.04167	12	12
0.05	0.03333	15	150
0.06	0.02778	18	180
0.07	0.02381	21	210
0.08	0.02083	24	240
0.09	0.01852	27	270
0.10	0.01667	30	300
0.11	0.01515	33	330
0.12	0.01389	39	390
0.13	0.01282	36	360
0.14	0.01190	42	420
0.15	0.01111	45	450
0.16	0.01040	48	480
0.17	0.00980	51	510
0.18	0.00926	54	540
0.19	0.00877	57	570
0.20	0.00833	60	600
0.21	0.00794	63	630
0.22	0.00758	66	660
0.23	0.00725	69	690
0.24	0.00694	72	720
0.25	0.00667	75	750
0.26	0.00641	78	780
0.27	0.00617	81	810
0.28	0.00595	84	840
0.29	0.00575	87	870
0.30	0.00556	90	900

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.31	0.00538	93	930
0.32	0.00521	96	960
0.33	0.00505	99	990
0.34	0.00490	102	1020
0.35	0.00476	105	1050
0.36	0.00463	108	1080
0.37	0.00450	111	1110
0.38	0.00439	114	1140
0.39	0.00427	117	1170
0.40	0.00417	120	1200
0.41	0.00407	123	1230
0.42	0.00397	126	1260
0.43	0.00388	129	1290
0.44	0.00379	132	1320
0.45	0.00370	135	1350
0.46	0.00362	138	1380
0.47	0.00355	141	1410
0.48	0.00347	144	1440
0.49	0.00340	147	1470
0.50	0.00333	150	1500
0.51	0.00327	153	1530
0.52	0.00321	156	1560
0.53	0.00314	159	1590
0.54	0.00309	162	1620
0.55	0.00303	165	1650
0.56	0.00298	168	1680
0.57	0.00292	171	1710
0.58	0.00287	174	1740
0.59	0.00282	177	1770
0.60	0.00278	180	1800
0.61	0.00273	183	1830
0.62	0.00269	186	1860

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.63	0.00265	189	1890
0.64	0.00260	192	1920
0.65	0.00256	195	1950
0.66	0.00253	198	1980
0.67	0.00249	201	2010
0.68	0.00245	204	2040
0.69	0.00242	207	2070
0.70	0.00238	210	2100
0.71	0.00235	213	2130
0.72	0.00231	216	2160
0.73	0.00228	219	2190
0.74	0.00225	222	2220
0.75	0.00222	225	2250
0.76	0.00219	228	2280
0.77	0.00216	231	2310
0.78	0.00214	234	2340
0.79	0.00211	237	2370
0.80	0.00208	240	2400
0.81	0.00206	243	2430
0.82	0.00203	246	2460
0.83	0.00201	249	2490
0.84	0.00198	252	2520
0.85	0.00196	255	2550
0.86	0.00194	258	2580
0.87	0.00192	261	2610
0.88	0.00189	265	2650
0.89	0.00187	267	2670
0.90	0.00185	270	2700
0.91	0.00183	273	2730
0.92	0.00181	276	2760
0.93	0.00179	279	2790
0.94	0.00177	282	2820

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm²	Net cpm = 5.0 Bq/cm²
0.95	0.00175	285	2850
0.96	0.00174	288	2880
0.97	0.00172	291	2910
0.98	0.00170	294	2940
0.99	0.00168	297	2970
1.00	0.00167	300	3000

DIRECT SURVEY



The direct survey method offers a direct measurement of external radiation dose rates enabling assessments of shielding needs and effectiveness. It is also the quickest and easiest method in some instances to assess surface contamination. A meter survey provides increased assurance that contamination “hot spots” will be detected and will also detect “fixed” contamination.

Routine Performance Checks Of Survey Meters:

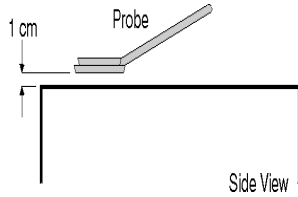
For instruments with needle indicators *before each use*:

1. Inspect the instrument carefully
 - ' are there indications it may have been dropped
 - ' is anything damaged on it
 - ' if the detector is used as a probe, does the cable show signs of breakage
 - ' is the meter free of contamination
 - ' is the needle in the zero position
 - ' does the needle bounce around excessively when the meter is moved
2. Turn the instrument on and allow it to warm up. If the meter was already on it may be that the last user forgot to turn it off and the batteries need replacing.
3. ***Turn to the battery check position and see that the batteries are good.***
4. Verify that the instruments audible response is working. You should always hear a few “clicks” due to background radiation.
5. Turn the range selector knob to the highest scale (least sensitive) and let the needle stabilize. Continue turning to more sensitive scales until a response is observed. The needle will fluctuate more on the lower scales because of the random nature of the detected events.
6. Check the response of the meter on each operational scale with a radiation check source that gives a reading close to the mid-scale. The readings should not deviate from the value by more than 10%.

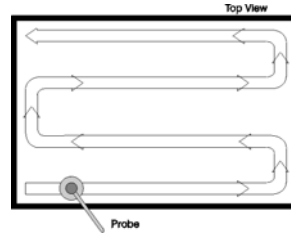
7. Have the instrument calibrated annually, if required by CNSC's document ***R-117, "Requirements for Gamma Radiation Survey Calibration"***.

Survey Procedure:

1. Select a suitable survey instrument for your needs (see accompanying table)
2. Pass the probe slowly over the area to be monitored taking care that the probe does not come into contact with the surface being monitored.



Measuring distance



Monitor in an "S" shaped motion

3. If the meter needle reads off scale, ***gently turn the range selection knob to a higher scale.***



- Record results and clean any contaminated areas.



Tips:

- ' always ensure that the instrument is turned **OFF** when not being used to preserve the batteries
- ' do not allow the instrument to get wet
- ' use care to avoid puncturing the “window” on the detector probe as this will render the unit unusable
- ' do not put undue stress on the instruments cable and cable connectors to avoid damage
- ' avoid exposing the unit to physical shock an/or extreme temperature changes
- ' **NEVER** change detector probes while the instrument is turned on.
- ' to ensure accurate detection **NEVER** adjust or tamper with the instruments high voltage.

Selection of Contamination Monitoring Instruments

Radioisotope	T ½	Principal Emission	Energy (keV)	Portable Instrument	Non-Portable Instrument
H ³	12.3 y	\$	5.7	6	B
C ¹⁴	5730 y	\$	49	1,2,3,6	A,B
P ³²	14.3 d	\$	690	1,2,3,6	A,B
P ³³	25.4 d	\$	85	1,2,3,6	A,B
Cr ⁵¹	27.8 d	(320	3,6	B,C,D
S ³⁵	87.4 d	\$	53	1,2,3,6	A,B
I ¹²⁵	60.1 d	(35	2,4,6	B,C,D

Hand Held Instrument

Thin window GM detector	1
Ion chamber with \$ window	2
Gas filled proportional counter	3
Thin layer NaI detector	4
Thin crystal NaI detector	5
“Sandwich” NaI detector	6
Zinc sulphide detector	7

Non-Portable Instrument

Gas flow proportional counter	A
LS counter	B
Well crystal NaI counter	C
Semiconductor (spectrometer	D

Sunday	Monday	Tuesday	Wednesda	Thursday	Friday	Saturday
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September

1	2	3	4	5	6	
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7	8	9	10	11	12	13
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14	15	16	17	18	19	20
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21	22	23	24	25	26	27
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28	29	30				
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DIRECT MONITORING FOR CONTAMINATION

Direct measurement means the use of portable radiation detection instruments to detect both fixed and removable (loose) contamination on a surface. Direct measurement may be used when background radiation levels are negligible compared to licence criteria. While the direct monitoring method has the advantage of allowing the operator to easily survey large and irregular surfaces, there are also disadvantages. This method does not indicate if the contamination is fixed or loose and cannot be used in high background areas. It cannot detect H-3 and may not be very effective with low energy beta emitters such as C-14 and S-35. The main advantage of the direct monitoring method over wipe testing is the speed of operation. For best results, the weekly wipe test should be complemented by daily spot checks with a portable contamination monitor.

The readings from portable contamination monitors can be related to licence criteria if the efficiency of the instrument for a specific nuclear substance is known. For mixtures do all calculations using the radioisotope for which the instrument has the lowest detection efficiency.

When performing direct monitoring the accompanying form is to be used. Negative results (< 0.5 Bq/ sq. cm.) require a check (U), positive results must be noted with follow up action taken.

Conversion tables follow which will allow you to convert cps or cpm to Bq/sq. cm.. Most Dalhousie laboratories use Ludlum meters equipped with a pancake probe, in which case you would refer to Table 5.

e.g. Detector efficiency for P-32	40 %
S-35, C-14	10 %

**EFFICIENCY CONVERSION TABLES:
HAND-HELD PORTABLE CONTAMINATION DETECTORS**

Quantifying Surface Contamination by Direct Monitoring

- T To obtain the surface contamination level in Bq/cm² multiply the net "direct monitoring" count rate by a suitable conversion factor
- T Find the row corresponding to the efficiency of your detector
- T Read the conversion factor in the adjoining column
- T Multiply each net count rate by the conversion factor to obtain surface contamination levels.
- T Table shown below represents table to be used with pancake probe (cpm output). Contact RSO for tables to be used with other types of probes.

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.01	0.1075269	5	46
0.02	0.0537634	9	93
0.03	0.0358423	14	139
0.04	0.0268817	19	186
0.05	0.0215054	23	232
0.06	0.0179211	28	279
0.07	0.0153610	33	326
0.08	0.0134409	37	372
0.09	0.0119474	42	418
0.10	0.0107527	46	465
0.11	0.0097752	51	512
0.12	0.0089606	56	558
0.13	0.0082713	60	605
0.14	0.0076805	65	651
0.15	0.0071685	70	698
0.16	0.0067204	74	744

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.17	0.0063251	79	791
0.18	0.0059737	84	837
0.19	0.0056593	88	884
0.20	0.0053763	93	930
0.21	0.0051203	98	976
0.22	0.0048876	102	1023
0.23	0.0046751	107	1070
0.24	0.0044803	112	1116
0.25	0.0043011	116	1163
0.26	0.0041356	121	1209
0.27	0.0039825	126	1256
0.28	0.0038402	130	1302
0.29	0.0037078	135	1349
0.30	0.0035842	140	1395
0.31	0.0034686	144	1442
0.32	0.0033602	149	1488
0.33	0.0032584	153	1535
0.34	0.0031626	158	1581
0.35	0.0030722	163	1628
0.36	0.0029869	167	1674
0.37	0.0029061	172	1721
0.38	0.0028297	177	1767
0.39	0.0027571	181	1814
0.40	0.0026882	186	1860
0.41	0.0026226	191	1906
0.42	0.0025602	195	1953
0.43	0.0025006	200	2000
0.44	0.0024438	205	2046
0.45	0.0023895	209	2093
0.46	0.0023375	214	2139
0.47	0.0022878	219	2186
0.48	0.0022401	223	2232

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.49	0.0021944	228	2279
0.50	0.0021505	233	2325
0.51	0.0021084	237	2372
0.52	0.0020678	242	2418
0.53	0.0020288	246	2465
0.54	0.0019912	251	2511
0.55	0.0019550	256	2558
0.56	0.0019201	260	2604
0.57	0.0018864	265	2650
0.58	0.0018539	270	2697
0.59	0.0018225	274	2743
0.60	0.0017921	279	2790
0.61	0.0017627	284	2837
0.62	0.0017343	288	2883
0.63	0.0017068	293	2929
0.64	0.0016801	298	2976
0.65	0.0016543	302	3023
0.66	0.0016292	307	3069
0.67	0.0016049	312	3116
0.68	0.0015813	316	3162
0.69	0.0015584	321	3208
0.70	0.0015361	315	3255
0.71	0.0015145	330	3301
0.72	0.0014934	335	3348
0.73	0.0014730	339	3395
0.74	0.0014531	344	3441
0.75	0.0014337	349	3488
0.76	0.0014148	353	3534
0.77	0.0013965	358	3581
0.78	0.0013786	363	3627
0.79	0.0013611	367	3674
0.80	0.0013441	372	3720

Detector Efficiency	Conversion Factor	Net cpm = 0.5 Bq/cm ²	Net cpm = 5.0 Bq/cm ²
0.81	0.0013275	377	3767
0.82	0.0013113	381	3813
0.83	0.0012955	386	3860
0.84	0.0012801	391	3906
0.85	0.0012650	395	3953
0.86	0.0012503	400	3999
0.87	0.0012359	405	4046
0.88	0.0012219	409	4092
0.89	0.0012082	414	4139
0.90	0.0011947	419	4185
0.91	0.0011816	423	4232
0.92	0.0011688	428	4278
0.93	0.0011562	432	4325
0.94	0.0011439	437	4371
0.95	0.0011319	442	4418
0.96	0.0011201	446	4464
0.97	0.0011085	451	4511
0.98	0.0010972	456	4557
0.99	0.0010861	460	4604
1.00	0.0010753	465	4650