Portable Radiation Survey Instruments

GUIDELINES FOR BASIC INSTRUMENT CARE
Portable radiation survey instruments, often called "geiger counters", are somewhat expensive items. In order to preserve the operational integrity and extend the useful life of your instruments, attention should be given to their proper care and maintenance.

1. Always ensure that the instrument is turned OFF (including the audible response switch) when not being used. This will preserve the batteries.
2. Do not allow instruments to get wet.
3. Use care to avoid puncturing the "window" on the detector probe. A punctured window will render the detector completely unusable.
4. Do not put undue stress on the instrument's cable and cable connectors, as they are easily damaged.
5. Avoid exposing the instrument to physical shock and/or extreme temperatures.
6. NEVER change detector probes while the instrument is turned "on". To do so may cause permanent damage to the detector, especially scintillation detectors.
7. To ensure accurate detection and measurement, NEVER adjust or otherwise tamper with the instrument's high voltage or calibration potentiometers.
8. When in use, avoid spreading radioactive contamination to survey instruments.

PRE-USE CHECKS FOR PORTABLE SURVEY INSTRUMENTS
Prior to performing surveys with your survey meter, always conduct the following pre-use checks to ensure that your instrument is functioning properly.

1. Check the instrument’s physical condition to verify that it is in good working order (cable and connectors; detector window, etc.).
2. Verify that the instrument’s battery voltage is within the acceptable range with the meter switched to the "battery" check position. IMPORTANT: Survey instruments MUST have adequate battery voltage to ensure their proper operation.
3. Verify that the instrument’s audible response is working. You should always be able to hear a few "clicks" due to background radiation, no audible response at all probably means that there is something wrong with the instrument, such as no battery voltage or a broken detector.
4. Verify that the instrument is currently calibrated. The calibration date should be noted on a label affixed to the side of the instrument. Also note the sticker on the top of the meter that identifies the mode of
detection (i.e., cpm or mR/hr). Each instrument is required to be calibrated at least annually. The Office of Environmental Health and Safety (EH&S) and UC Davis Health (UCDH) Health Physics are certified to calibrate most radiation survey instruments and this service is provided at no cost to the UC Davis researchers.

5. When possible, perform a quick response check of the instrument. Measure an item that is known to be radioactive to verify that the instrument will indeed respond to radiation. Ensure that both the audible and the meter response are functioning.

**TYPICAL DETECTOR PROBES USED WITH PORTABLE RADIATION SURVEY INSTRUMENTS**

**GM Detectors ("Geiger-Muller")**

1. End-Window GM Detector Probe
   1. Used for detection of medium to high energy beta radiation (responds best for $^{32}\text{P}$).
   2. Least sensitive of all the types of detectors for detecting low levels of radiation.

2. Pancake GM Detector Probe
   1. Used for detection of medium to high energy beta radiation (best for $^{32}\text{P}$, but also can detect $^{35}\text{S}$, $^{45}\text{Ca}$, $^{14}\text{C}$ and other medium-energy beta particles).
   2. Due to differences in their detectors surface area, the pancake detector has greater sensitivity for low levels of radiation than does the end-window detector.
   3. The enhanced sensitivity of this detector requires that it be used in areas with low levels of background radiation.

**NOTE:** The end-window and pancake GM detectors described are primarily considered to be beta radiation detectors. It should be noted that these detectors will detect some electromagnetic radiation (gamma and x-ray), however, they are extremely inefficient, and generally should not be used for this purpose.

**Scintillation Detector**

1. Sodium Iodide (NaI) Detector Probe
   1. This detector consists of a sodium iodide crystal and a photomultiplier tube. It is very fragile and sensitive to light.
   2. This detector is primarily used for detection of low-energy gamma and x-ray radiation. It is best used for detecting $^{125}\text{I}$ and $^{51}\text{Cr}$, and to check for secondary x-ray production ("bremsstrahlung") when working with large amounts of high-energy beta emitters like $^{32}\text{P}$.
   3. This detector is extremely sensitive, therefore it must be used in a low background area to obtain meaningful results. The NaI detector typically is only useful for the purpose of determining whether radiation fields or contamination above background levels is present on a surface or in a particular location. It should not be used to quantify an amount of radioactivity or to define the intensity of a particular radiation field (i.e., determine "exposure rate").

**REQUIREMENTS FOR SURVEYS BY INDIVIDUAL WORKERS**

1. Each individual user must perform contamination surveys of work areas immediately upon completion of work with radioactivity. These surveys should consist of both a meter scan and wipe tests, and are necessary to verify that work areas are free of radioactive contamination. Written records of these
surveys are not required to be maintained.
Areas to be surveyed must include:
1. Immediate work area (benches, fume hoods, walls, floors).
2. Any equipment and/or tools exposed to radioactivity.
3. Any other surfaces or items which may have inadvertently become contaminated, such as: cabinet/drawer handles; chairs; refrigerator/freezer handles; calculators; timers; sinks; pens; papers; etc.
4. Your laboratory coat; give special attention to the sleeves, cuffs, and pockets.
5. Your body. Give special attention to the hands (especially fingertips and nails) and the face.
   METER SURVEY ONLY - DO NOT WIPE TEST THE SKIN!

2. Bi-weekly surveys are required of laboratories that use/handle ANY quantity of radioactivity during any two week period. These surveys must consist of both a meter scan and wipe tests. Written records including the liquid scintillation or gamma well printouts of bi-weekly surveys are required to be maintained in the laboratory for periodic review by the EH&S Health Physics staff and/or the State of California, Department of Public Health, Radiologic Health Branch.
Areas to be surveyed include:
1. All radioactive work areas (benches, hoods, etc.).
2. Equipment and tools used in conjunction with radioactivity (i.e., pipettes, microfuges, shakers, etc.).
3. Shielding and radioactive waste containers.
4. Door handles (refrigerators, freezers, cabinets, etc.).
5. Floors
6. Sinks
7. Telephones
8. Controlled Areas
9. Desk tops and personal items such as calculators, timers, pens, papers, notebooks, computers, etc.
10. Chairs
11. Etc.

NOTE: If no radioactive material was used within the laboratory during the two week period, then the requirement to conduct and document a bi-weekly survey may be waived. An entry such as "NO RADIOACTIVE MATERIAL USE" should be made in the laboratory’s radiation monitoring log book for that two week period.

SURVEY PROCEDURES AND METHODS

Ambient Radiation Level Surveys
These types of surveys are conducted within your work areas and are used to determine the ambient radiation levels caused by radioactive materials used or stored in your areas. Such types of measurements
can only be taken with an ion chamber or a properly calibrated survey meter equipped with a GM detector probe. Most laboratories at UC Davis do not possess ion chamber instruments. When using a GM-equipped meter, it must be capable of measuring as low as 0.1 mR/hr, if it is equipped with such a scale.

Results should be recorded in the laboratory monitoring log book and indicate the location, date, name of person performing the survey, instrument used (model and serial number), exposure levels (mR/hr or cpm), and any corrective action taken, if needed. A sketch of the area is necessary for recording the data.

**Contamination Level Surveys**
The only true survey for loose (removable) surface contamination is the wipe test survey method. However, prior to taking wipe samples, an initial check for contamination can be performed using a survey meter to directly monitor surfaces of interest.

Use a survey meter with an appropriate detector probe to survey bench tops and other work areas. A survey instrument can be used to perform a relatively quick check of the work area to draw attention to areas requiring possible decontamination. If any areas are found which exceed background radiation levels, then decontamination procedures would be worthwhile at this point prior to taking wipe samples.

Using filter paper discs or cotton swabs, take a series of wipes from working surfaces where contamination could be expected to exist or where radiation levels are elevated. Each wipe should be numbered and the location where they are taken shown on the sketch as described above for radiation surveys. The wipes should be rubbed firmly over a surface area of about 100 cm² (approximately 4”x4”) in order to consistently determine the amount of removable surface contamination.

The wipes must be analyzed using a gamma or liquid scintillation counter, as appropriate. Compare the sample results to the background sample. In contamination control zones, the amount of removable contamination cannot exceed 300 counts over background. Controlled areas within the laboratory cannot exceed 60 counts over background. For more detailed information regarding the UC Davis contamination limits, refer to the Radiation Safety Manual, Section V., Handling Requirements.

**Techniques for Using Portable Radiation Survey Instruments**
When using portable radiation survey instruments, it is essential that the proper techniques be employed to assure accurate results. Failure to use correct techniques usually results in an inadequate survey.

1. The detector’s "window" should be held as close as possible (within about 1 cm (1/2 ")) to the surface being measured. Use extreme care to avoid actually touching surfaces and spreading radioactive contamination to the detector. Remove plastic coverings, if present, from the detector window as this will effectively shield out lower energy radiations and preclude their detection.

2. Scan surfaces slowly enough to detect the presence of low levels of radioactive contamination. Typically, the rate of detector movement should not exceed about 1” to 2” per second.

3. Always use the instrument’s audible response while conducting surveys. The audible response is much faster than the meter indication. While scanning areas, listen to the "clicks" of the instrument rather than relying on meter deflection. What you are listening for is any increase in the rate of "clicks" above normal background levels. When you note any increases, stop and scan that area more thoroughly. Any sustained increase above background levels should be investigated.
4. Ensure that you select the proper scale on the instrument for conducting the survey. Whenever scanning surfaces for radioactive contamination, always use the lowest scale (i.e., x0.1 or x1 scale) available. Select higher range scales as necessary to obtain maximum readings if contamination or other measurable radiation is detected.

IMPORTANT: Remember that tritium (³H) is such a low-energy beta emitter that it can not be detected by direct scan with any survey meter. WIPE TESTS ONLY!!

Techniques for Conducting Wipe Test Surveys for Surface Contamination

1. ALWAYS wear a clean pair of gloves and change them during the survey if you know or suspect that they have become contaminated. This ensures that you will not cross-contaminate any wipe samples.

2. Use filter paper discs as your wipe material. Dry wipes are normally used because they will more closely represent the spread of contamination that would occur due to personnel brushing against contaminated surfaces. It is acceptable to use wipes that have been slightly moistened, if desired.

3. To perform the survey, rub the wipe material firmly over a 100 cm² area of the surface of interest.
   1. The 100 cm² wipe area is widely used for loose surface contamination surveys. The reasons for using this wipe area are:
      1. this area provides nearly an optimum efficiency for collecting and measuring loose surface contamination;
      2. this is a convenient area to measure; and
      3. wipe materials tend to disintegrate when wiped over larger areas.

4. ALWAYS assign a number to each wipe AND make a sketch or use some other type of record to indicate where each individual wipe sample was taken.

Procedures for Counting Wipe Samples

1. Liquid Scintillation Counting (LSC) [USE FOR ANY RADIOISOTOPE]
   1. Deposit wipe sample into a clean scintillation vial.
   2. Fill the vial at least 2/3-full with scintillation cocktail.
   3. Tightly cap the vial.
   4. Mix the contents of the vial thoroughly.
   5. Count the sample for at least 1 minute in a liquid scintillation counter. ALWAYS INCLUDE A "BACKGROUND" VIAL (an unused wipe prepared with cocktail). For an even better background sample, take a wipe of common non-radioactive dust so that the background is consistent in dust content as your laboratory samples.
   6. Examine the counting results. Any wipe sample in a contamination control zone indicating radioactivity levels of 300 counts over background requires that the surface of concern be decontaminated. Any wipe sample in a controlled area indicating radioactivity levels of 60 counts above background must be decontaminated. All affected surfaces must be CLEANED and REWIPED until loose surface contamination is reduced below those respective limits.

2. Gamma Scintillation Counting [USE FOR GAMMA-EMITTING RADIOISOTOPE]
   1. Deposit wipe sample in a clean scintillation vial. (DO NOT USE COCKTAIL)
2. Count the sample for at least 1 minute with a gamma scintillation counter. ALWAYS INCLUDE A "BACKGROUND" VIAL.

3. Examine the counting results. Any wipe sample in a contamination control zone indicating radioactivity levels of 300 counts over background requires that the surface of concern be decontaminated. Any wipe sample in a controlled area indicating radioactivity levels of 60 counts above background must be decontaminated. All affected surfaces must be CLEANED and REWIPED until loose surface contamination is reduced below those respective limits.

3. Important Notes Regarding Scintillation Counting
   1. Scintillation counters should come equipped with a set of radioactive counting "standards" which are to be analyzed by the counter periodically to check its operation. Ideally, the standards should be counted as often as the scintillation counter is used for counting samples, i.e., daily or weekly. Scintillation counters should be scheduled for routine and preventive maintenance by a qualified service technician to ensure that they will provide reliable counting results.
   2. Whenever possible, select a liquid scintillation cocktail that is biodegradable and requires little special handling, storage, or disposal.
   3. Factors that affect the counting results of samples include: counting time, sample volume, sample distribution and geometry, background radiation, efficiency of the counter for measuring certain radiation energies.

Survey Methods Required for Commonly-Used Radioisotopes
In order to assure that surveys for ionizing radiation and radioactive contamination are reliable, it is essential that personnel use the correct detector and survey method as determined by the radioisotope of concern. The following table delineates which type of detector and survey method are required for most of the frequently-used radionuclides at UC Davis.

METHOD 1: Liquid Scintillation Wipe Test

METHOD 2: Gamma Scintillation Wipe Test

METHOD 3: Survey meter scan using Pancake GM detector

METHOD 4: Survey meter scan using End-Window GM detector

METHOD 5: Survey meter scan using NaI Scintillation detector

<table>
<thead>
<tr>
<th>Radioisotope</th>
<th>Survey Method(s) Required</th>
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<tbody>
<tr>
<td>3H</td>
<td>#1</td>
</tr>
<tr>
<td>35S</td>
<td>#1 AND #3</td>
</tr>
<tr>
<td>45Ca</td>
<td></td>
</tr>
<tr>
<td>14C</td>
<td></td>
</tr>
<tr>
<td>33P</td>
<td>#1 AND #3 or #4</td>
</tr>
<tr>
<td>32P</td>
<td>#1 AND #3 or #4</td>
</tr>
<tr>
<td>125I</td>
<td>#1 or #2 OR #5</td>
</tr>
<tr>
<td>131I</td>
<td></td>
</tr>
<tr>
<td>75Se</td>
<td>#1 or #2 AND #3, #4 OR #5</td>
</tr>
<tr>
<td>51Cr</td>
<td></td>
</tr>
<tr>
<td>86Rb</td>
<td></td>
</tr>
<tr>
<td>59Fe</td>
<td></td>
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LIMITS FOR SURFACE CONTAMINATION
Loose Surface Contamination Limits
Removable contamination on surfaces must not be permitted to exist in excess of limits stated in the UC Davis Radiation Safety Manual, Section V., Handling Requirements as determined by a wipe survey OR in excess of background levels as determined by a direct meter scan.

The basis for the loose surface contamination control limits are:

- The limits are set low enough to minimize the potential for ingestion of significant amounts of radioactivity by personnel;
- The limits are set low enough to minimize the potential for the creation of airborne radioactivity.
- The limits are set near natural background levels of radioactivity so as not to cause an increase in environmental radioactivity levels over large areas. [most restrictive consideration]

If the UC Davis contamination limits are exceeded, the area(s) of concern must be cleaned until the contamination has been removed or is stabilized (“fixed”). Additionally, the EH&S Health Physics staff strongly recommends that when surveys indicate any detectable radioactivity exists above background levels, that these areas be cleaned to remove all radioactive contamination. This action should help prevent the spread and ingestion of even minor amounts of radioactive material.

Fixed Surface Contamination Limits
Stabilized or fixed radioactive contamination on surfaces is controlled based upon the levels of radiation it emits. The use of temporary shielding will be required for surfaces producing an open window meter reading of 0.5 mR/hr or more. An example would be securing a piece of plexiglass shielding to the floor or a benchtop because of fixed $^{32}$P contamination. After the passage of a sufficient number of radioactive half-lives, typically 7 - 10, the shielding can be removed and the area of concern surveyed to verify levels are within the acceptable limits.

Fixed radioactive contamination from long-lived radioisotopes may require more extreme measures such as removal and disposal of the contaminated surfaces (floor tiles, wall material, furnishings, etc.). Contact EH&S (530-752-1493) when you are contemplating any removal and disposal option.

Contact

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More information

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