RADIOISOTOPE LABORATORY SAFETY PROCEDURES

PURPOSE

This procedure provides criteria and specific instructions for safe handling of radioisotopes in unsealed or dispersible forms, including contamination control and monitoring of exposures. It also specifies the requirements for monitoring records to be maintained by the users.

POLICY

It is the responsibility of each radiation user to be thoroughly familiar with the University's ***Radiation Safety Policy Manual*** and the Radiation Procedures and Records (RPR's) applicable to his or her work, to follow safe work practices, to be aware of actual or potential radiation exposures, and to keep all exposures to levels that are as low as reasonably achievable (ALARA). Each person who handles unsealed or dispersible radioisotopes is responsible for the control and containment of radioactivity and for performing regular surveys of personnel, personal effects, equipment and work areas using methods that will assure the detection of contamination before significant exposures occur.

The responsible user must assure that the necessary monitoring is performed, recorded and reported. Routine evaluations of all radioisotope laboratories, including surveys for contamination, are also performed by the RSO.

RESPONSIBILITIES

Each person who works with unsealed or dispersible radioactive materials is responsible for:

1 knowing the basic properties of the radioactive materials to be used, e.g. the half-life of the nuclide(s), the type(s) of radiation emitted, the annual limit on intake (ALI), the removable contamination limit (RCL) and any shielding that may be required. See "RADIONUCLIDE DATA" (RPR 10).

2 following the instructions or procedures provided by the responsible user and the RSO, or provided in the *Radiation Safety Policy Manual*.

3 wearing a laboratory coat or other protective clothing and disposable gloves at all times when licensed material is handled.

4 surveying of hands, gloves, clothing, equipment and work area frequently during procedures in which more than 1 ALI is manipulated, and **before leaving the laboratory**.

5 providing a urine sample, or obtaining a thyroid count, at intervals specified by the RSO. See "BIOASSAYS FOR INTERNAL RADIOACTIVITY" (RPR 12).

6 **recording the results of all radiation surveys** and screening bioassays promptly, completely and accurately.

The Responsible User (RU) must ensure that:

1 all radiation users have received the required radiation safety instruction.

2 the equipment, supplies and services necessary for radiation protection are provided.

3 all applicable lab safety precautions are followed, including the prohibition against consumption or storage of food and beverages in the lab.

4 radioactive materials are secured against theft, misuse and access by unauthorized personnel.

5 radioactive wastes are segregated properly and placed in appropriate containers. Containers are to be provided by the user; labels are available from the RSO. Follow the instructions in "RADIOISOTOPE ACQUISITION AND DISPOSITION" (RPR 13).

6 accurate records of acquisitions and dispositions of radioactive materials are maintained. Refer to "RADIOISOTOPE ACQUISITION AND DISPOSITION (RPR 13).

7 regular exposure and contamination surveys are performed and recorded.

8 the RSO is notified promptly of any accident or abnormal incident involving radioactive materials.

9 prior to any extended absence, another individual is authorized by the Radiation Safety Committee to assume the preceding responsibilities, or the use of radioactive materials is suspended or terminated.

POSTING RADIOISOTOPE LABORATORIES

Each room containing more than 10 reference quantities (RPR10) of all radioisotopes combined must be labeled with a "CAUTION RADIOACTIVE MATERIALS" label. This label shall indicate the isotopes present, and the name and phone numbers (home and office) of the responsible user or other individual specifically designated to be responsible for emergencies.

A "NOTICE TO WORKERS", provided by the Utah Division of Radiation Control and available from the RSO, shall be posted where anyone entering the lab can see it.

If any dose rate exceeds 2 mrem/hour at 30 cm (1 ft.) from an accessible source or surface, the room is a "Restricted Area" and must be posted to prevent entry of unauthorized individuals. **If any dose rate exceeds 5 mrem/hour at 30 cm** (1 ft.) from an accessible source or a surface, the room must be labeled with a "CAUTION RADIATION AREA" sign. **Unless otherwise specified for specific facilities, 5 mrem/hour shall be the action level requiring notification of the RSO.**

STORAGE OF RADIOACTIVE MATERIAL

Each container of licensed material containing more than the quantity specified in table below shall be clearly labeled with the trefoil radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". The label shall also indicate the isotope(s) present, an estimate of the activity and the date for which the activity is estimated.

Quantities of Radioactive Material Requiring Labeling	
Radionuclide	Quantity (μCi)
H-3	1,000
C-14	100
Na-22	10
P-32	10
P-33	100
S-35	100
Cl-36	10
Rb-86	100
In-111	100
I-125	1
I-131	1
*for nuclides not listed contact the Radiological Health Department	

RADIATION SURVEY INSTRUMENTS

The responsible user shall ensure that instruments used for determining exposure rates or for direct detection of contamination are capable of responding appropriately to the kinds of radiation anticipated and have been calibrated within the past year. For most radioisotope laboratories, a thin-window Geiger-Mueller (GM) survey meter with an audible response is best. For low-energy photon emitters, (I-125, Cr-51, Tc-99m, etc.) a thin-crystal scintillation detector, also with audible response, is preferred.

The user must know the detection efficiency for each survey instrument and record it with all survey results. **Detection efficiency is the fraction of the emissions (usually 1 per disintegration) from any source to**

which the instrument responds under conditions of normal use; e.g. counts per disintegration, cpm/dpm, etc. The reporting forms attached to this procedure include provisions for recording all pertinent instrument data.

In laboratories where only tritium (H-3), or less than 1 ALI of other low-energy beta emitters are used, direct surveys are not appropriate and all contamination surveys shall be made by means of wipe tests.

If an analytical instrument is to be used for counting urine samples or contamination wipe tests, the user must know the detection efficiency for each sample type and for each anticipated nuclide. The user may obtain help from the RSO to determine appropriate sample sizes and counting times for urine samples, and the results that would require verification.

TROUBLE SHOOTING SURVEY METERS

Instruments used for contamination surveys are not required to provide extremely accurate results, but they must provide consistent indications of the presence or absence of contamination. If a meter gives inconsistent or questionable results, check the following conditions before sending it for repair or recalibration.

1 **Check the battery!** Turn the selector to the "Battery" position for at least 30 seconds to verify that the battery is in good condition. If the battery is low, replace it.

2 **If the meter reads higher than its normal background, use another reliable meter to check for external contamination.** Contamination becomes a problem when users neglect to monitor their hands during radiolabeling processes. **Meters should be included when performing both personal and area surveys.3**If the meter is contaminated, clean it carefully to remove the contamination. **If contamination with a short-lived nuclide cannot be removed down to background, remove the batteries, label the meter with "CAUTION RADIOACTIVE MATERIAL" tape, place it in a labeled plastic bag, and set it aside for decay.** When the contamination has decayed down to background, the meter should be recalibrated if the annual calibration period has been exceeded. For contamination with long-lived nuclides, it may be necessary to disassemble the meter and replace some components.

4 **If discrepancies are observed between the readings from two meters, first check the efficiencies indicated on the calibration label**. Small discrepancies may represent actual differences in the sensitivities of the instruments. If the discrepancies are not due to differences in efficiencies, the problem may be in the electronics or in the calibration of one or both meters. First ask Radiological Health to verify the calibration; then obtain repairs, if necessary.

5 Before removing a meter from the lab, survey it to assure that no contamination is present.

6 If a meter has been sent in for repair, the meter must be recalibrated by Radiological Health before being put back into use.

EXTERNAL EXPOSURE CONTROL

Potential external radiation exposures from gamma and high-energy beta-emitting sources and radiation producing machines are evaluated by the RSO to determine personal monitoring requirements. When personal dosimeters are specified it is important that they be worn properly at all times where licensed material is stored or used. They must also be exchanged at the proper time intervals. Specific procedures for wearing and exchanging personal dosimeters are provided in the ***Radiation Safety Policy Manual***. These procedures also include provisions for special handling fees for dosimeters that are not exchanged according to schedule. It is the responsibility of each radiation user who has been issued dosimeters to be thoroughly familiar with these procedures.

Careful planning of work, good handling techniques and thorough monitoring are all necessary to minimize exposure. Adequate shielding and distance from sources are also important factors in reducing exposure. Iodine-125 should be shielded with at least 3 mm (1/8") of lead. Other nuclides that emit higher energy gamma rays may require 5 cm (2") or more of lead. The shielding must extend entirely around the source; verify by making measurements of exposure rates above, below, in back and at the sides of storage locations.

The potential quarterly gamma dose from each radionuclide used may be estimated as:

$D = A \bullet X \bullet T(1/d^2)$, where:

D = estimated dose (millirem/quarter)

A = activity handled (millicuries)

X = external dose-rate constant

(mrem/hr at 1 m from 1 mCi) (see RPR 10A)

T = exposure time (hours/quarter)

$1/d^2$ = distance correction

= 10,000 for contact hand dose,

i.e. $(1/0.01\ m)^2$ for d = 1 cm

= 100 for hand dose using tongs,

i.e. $(1/0.1m)^2$ for d = 10 cm

= 10 for body dose during entire handling time, i.e.

$(1/0.3m)^2$ for d = 30 cm

SPECIAL INSTRUCTIONS FOR P-32 USERS

The dose rate to the skin from high energy beta-particle emitters, e.g. P-32, may be extremely high at close range. For example, the contact dose rate from 1 mCi of P-32 in 1 mL solution with no shielding is approximately **10,000 mrem/minute**, whereas at 1 meter, the dose rate would be approximately 10 mrem/hour.

For P-32 or other high-energy beta emitters, a shield made of any plastic material 1 cm (3/8 inch) thick will absorb the beta particles while generating little secondary radiation (bremsstrahlung). For millicurie quantities of P-32, lead shielding at least 3 mm (1/8") thick should be added to the exterior of the plastic to absorb the more penetrating secondary radiation.

Ring badges are issued to individuals whose hand or finger doses may exceed 1,000 mrem per calendar quarter. The requirement for monitoring is based on the nuclide(s) used, and the activity (mCi) handled monthly by the individual. **An individual who has been issued a badge is required to wear it whenever handling radioactive materials**. The badge itself offers no protection; however, it provides valuable information that is necessary to ensure that exposures are kept ALARA.

The ring badge should be worn so that the name label faces the source, i.e. away from the palm of the hand. For example, when pipetting P-32 from a vial, the ring badge should be worn on the little finger of the hand holding the pipette with the name label facing the mouth of the vial. The dose rate at the mouth of an open vial containing 1 mCi of P-32 in 1 mL of liquid may be as high as 10 rem/minute. **Exposure can be markedly reduced by not picking up tubes when radiolabeling**.

To avoid contamination of the ring badge, always wear it under gloves. Verify that it has not become contaminated by including it in your routine personal and area surveys. Always store your badge away from heat, as well as radiation sources.

EXPOSURE RATE SURVEYS

A survey of exposure rates must be performed when sources of penetrating radiation are first acquired, when the quantities of these nuclides are increased and when physical arrangements for handling or storage are modified. Additional surveys should be performed occasionally to assure that inadvertent changes in exposure rates have not occurred. If the user does not have a survey instrument that is calibrated for exposure-rate measurements, a survey should be requested from the RSO.

PREVENTION OF INTAKE OF RADIOACTIVE MATERIAL

Ingestion of radioactivity must be prevented by **avoiding mouth contact** with any items handled in a radioisotope laboratory (pipettes, pencils, etc.) by **prohibiting eating, drinking, smoking or applying cosmetics** in radionuclide handling areas and by careful attention to personal hygiene. Storage of these personal effects in areas where licensed material is stored or used is also prohibited. **Never pipette by mouth..**

Gloves, lab coats, or other protective clothing, should be available and worn to prevent contamination of skin and personal clothing. **Lab coats and gloves should not be worn to the cafeteria, library, classrooms or home**. Sandals or other open-toed shoes and shorts are not appropriate for work with radionuclides.

Work, storage and waste areas should be provided with secondary containers and covered with absorbent paper. Plastic trays and dish pans are suitable for use as secondary

containers. The protective covering should be replaced when it becomes excessively dirty or contaminated.

Inhalation of radioactive materials must be prevented by performing all operations that release gases, vapors or dusts in approved fume hoods. The sash of a fume hood is intended to serve as a shield to protect the face from spatters, as well as to control air flow. To provide the proper protection, the hood must be free of major obstructions to the flow of air and the sash should be set at the height that was indicated with a label when the air flow rate was measured. The average face velocity should be 100 ± 20 fpm. If the desired velocity cannot be maintained, the user must notify the department of Environmental Health and Safety (EHS) to arrange for repairs or modifications.

In emergency situations, filtered or supplied-air respirators may be used by emergency responders to prevent inhalation of contaminants. Whenever the probability of airborne contamination is significant, the RSO should be notified and air sampling may be required.

CONTAMINATION SURVEYS

Surveys for contamination on the hands and clothing must be performed immediately after working with radioisotopes to allow detection and removal before the material enters the body. Application of the ALARA principle dictates that no removable contamination shall be tolerated indefinitely. Whenever contamination is detected, it must be removed promptly to prevent its spread and the possible exposure of other individuals. Any radioactive material on the skin must be removed promptly by normal washing. If it cannot be removed easily, request advice from the RSO.

A thorough survey of the entire laboratory must be **performed and recorded by the user** in each radioisotope laboratory on a regular basis according to the level of use, as indicated below.

The required frequency for performing routine laboratory surveys is determined by the nature and quantities of radionuclides, and the conditions of use. For laboratories where unsealed or dispersible radioisotopes are used, the frequency of routine contamination surveys is based on the total quantity of these materials present at any time during a bioassay interval, expressed in ALI's (RPR10). The "interval inventory" is the number of ALI's on hand at the beginning of the interval plus the total number of ALI's acquired during the interval.

The nominal survey frequencies shown in the table are to be interpreted as guidelines. In cases where contamination occurs regularly, the interval between surveys should be shortened. **A laboratory survey must be performed following the cleanup of a spill or contamination event**.

Measurements of contamination by direct detection, wipe tests, or both, should be made of representative surfaces. An audible instrument response should be used during direct surveys because of the faster and more sensitive response and because it eliminates the need to watch the meter constantly.

To determine quantities of removable contamination, or to survey areas that are inaccessible to a survey instrument, wipe tests shall be taken. An area of 100 to 300 cm^2 should be

INTERVAL* INVENTORY	**ROUTINE CONTAMINATION SURVEY FREQUENCY**
<1 ALI	**Personal surveys EVERY DAY and laboratory surveys EVERY MONTH** when radionuclides are in use.
1-30 ALIs	**Personal surveys EVERY DAY and laboratory surveys EVERY WEEK** when radionuclides are in use.
>30 ALIs	**Both personal and laboratory surveys EVERY DAY** when radionuclides are actually in use.

* Monthly average during the bioassay interval.

wiped with absorbent paper for each test. If energetic beta emitters are involved, the activity on the filter may be measured directly with a thin-window GM survey meter. If tritium or other low-energy beta emitters are involved, the wipe filter should be analyzed with a liquid scintillation counter.

CONTAMINATION SURVEY DATA

1 Unless the only nuclides used are tritium or small quantities (<1 ALI) of other low-energy beta emitters, a direct survey should be made with a portable instrument. For each portable survey instrument used, record the make, model and serial number(s) of survey meter(s) used for the survey on the ""CONTAMINATION SURVEY - PORTABLE INSTRUMENT" (RPR 11A). Indicate the calibration date and the detection efficiency for the **critical nuclide**, i.e. the **one with the largest number of ALIs** in use. Calculate the net response rate expected from the instrument for the removable contamination limit (RCL)(RPR 10). Note that all of the instrument response information needs to be entered only once until the instrument is recalibrated.

2 With the audible response turned on, move the detector slowly over all surfaces that might be contaminated, holding the detector 1-2 cm from the surface. Record the highest net response for each object or location surveyed, following the instructions on the form under "CONTAMINATION SURVEY RESULTS".

3 At locations with positive survey results, first ascertain whether the reading could be penetrating radiation coming through the surface, rather than from contamination on the surface. If significant penetrating radiation is detected, i.e. more than 0.2 mrem/hr (approximately 10 times background), an exposure rate survey should be made as previously described.

4 At locations with positive results from contamination, or surfaces that are not accessible for a direct measurement, use a dry filter paper to take a wipe of 300 (preferred) or 100 cm^2. (A 300 cm^2 area is any equivalent of a 7-inch square or a strip 2 cm wide and 1.5 meter long; a 100 cm^2 area is any equivalent of a 4-inch square or a strip 1 cm wide and 1 meter long.)

5 Using the portable survey instrument in a low-background location, make a direct measurement of the contamination on the filter paper. Record the results according to the directions on the survey form.

6 If contamination from low-energy beta emitters, e.g. C-14, S-35, is detected at a level close to the RCL, the wipes should be kept and counted in a liquid scintillation counter.

7 If only tritium or small quantities of other low-energy beta emitters are used, take wipe samples of all objects and surfaces that are normally touched or readily accessible.

8 On the "CONTAMINATION SURVEY - WIPE TESTS" form (RPR 11B), record the data identifying the counting instrument, the efficiencies for the critical nuclide and the expected response for a wipe with more than the RCL.

RSO EVALUATIONS

An evaluation of the radiation protection status of each radioisotope laboratory, including a contamination survey, will also be performed by or on behalf of the RSO. Specific procedures can be found in RPR 50, Radioisotope Laboratory Evaluations.

RADIOACTIVE MATERIAL SECURITY

All radioactive materials in laboratories must be kept physically secure from theft or unauthorized use. Radioactive sources should be kept in a **locked** storage cabinet, box, refrigerator or freezer when not actually in use. When radioactive materials are in use or accessible in the laboratory, such as radioactive samples or radioactive wastes, they should be kept under surveillance at all times. Whenever the laboratory containing such accessible materials is unoccupied, even if only for short periods, the laboratory **must be locked**.

RECORDS

All radioisotope inventory forms must be kept up to date and forwarded to the RSO as soon as the material item is used up. Sink disposals should be logged and summarized on the inventory disposition form. Refer to "RADIOISOTOPE ACQUISITION AND DISPOSITION" (RPR 13) for instructions.

The results of radiation surveys are to be recorded and retained for a minimum of three (3) years. They are to be made available for review and evaluation by the RSO, the RSC, or the appropriate licensing agency. Recommended forms (RPR 11A and 11B) for recording survey results are

attached to this procedure; however, other formats that provide comparable information may be used.

Personnel surveys should indicate the name of the individual surveyed and, if any contamination was found, the location on the body or on the clothing.

REFERENCES

Utah Department of Environmental Quality, Division of Radiation Control:

Utah Radiation Control Rules, Standards for Protection Against Radiation, Chapter R313-15.

Utah Radiation Control Rules, Medical Use of Radioactive Material, Chapter R313-32.

RPR 11A. CONTAMINATION SURVEY - PORTABLE INSTRUMENT

Page 1 of survey record initiated by _____ (name) on _____ (date)

User: _____ Group: _____ Bldg/Room(s): _____

Nuclides used: _____ Critical nuclide: _____ ALI: _____ mCi

Removable contamination limit (RCL): _____ dpm per 100 cm^2 (See RPR10)

SURVEY INSTRUMENT RESPONSE TO CRITICAL NUCLIDE

Survey Instrument(s) Used			Instrument Calibration		Expected Net Response to 1 RCL (cpm or cps)		
					[1]	[2]	[3]
Make, Model, Ser. No.	Calib. Date	Bkgd. Rate (cpm/cps)	Isotope	Detection Efficiency	Direct	Wipe of 100 cm^2	Wipe of 300 cm^2
1.							
2.							
3.							

[1] RCL x Detection Efficiency [2] RCL x Detection Efficiency [3] 3 x RCL x Detection Efficiency

CONTAMINATION SURVEY RESULTS

[A] Repeated entries for persons or locations that are surveyed regularly may be identified by initials or a code letter following a clearly identified entry on the same or previous sheets.

[B] Enter "D" for a direct measurement, "100" for a 100 cm^2 wipe or "300" for a 300 cm^2 wipe.

[C] Net count rate of meter with probe near the contaminated surface or the wipe filter.

[D] If the count rate in [C] is greater than the expected response to 1 RCL, as listed above, enter the multiple of the RCL.

Survey Date	Inst. # Used	[A] Object, Location in Room or Name of Person	[B] Area (cm^2)	[C] Net Rate (cpm)	[D] Multiple of RCL	Surveyed By

ALL SURVEY RECORDS MUST BE RETAINED FOR AT LEAST THREE YEARS

RPR 11A. CONTAMINATION SURVEY - PORTABLE INSTRUMENT

Continuation sheet # _____ of record initiated on _____ (Date)

User: _____ Group: _____ Bldg/Room(s): _____

Nuclides used: _____ Critical nuclide: _____ ALI: _____ mCi

Removable contamination limit (RCL): _____ dpm per 100 cm^2 (See RPR10)

Survey Date	Inst. # Used	[A] Object, Location in Room or Name of Person	[B] Area (cm^2)	[C] Net Rate (cpm)	[D] Multiple of RCL	Surveyed By

ALL SURVEY RECORDS MUST BE RETAINED FOR AT LEAST THREE YEARS

RPR 11B. CONTAMINATION SURVEY - WIPE TESTS

Page 1 of survey record initiated by _____ (name) on _____ (date)

User: _____ Group: _____ Bldg/Room(s): _____

Nuclides used: _____ Critical nuclide: _____ ALI: _____ mCi

Removable contamination limit (RCL): _____ dpm per 100 cm^2 (See RPR10)

COUNTING INSTRUMENT DATA

Type: LSC ☐ Gamma ☐ Other ☐ Model, serial #: _____

Program/Setup: _____ Preset: _____ minutes or _____ counts

Units of Readout: _____

Counting Channel:	**[1]**	**[2]**	**[3]**
Background:			
Critical nuclide efficiency:			
Expected Net Response to 1 RCL:			

WIPE TEST COUNTING RESULTS

[A] Repeated entries for persons or locations that are surveyed regularly may be identified by initials or a code letter after a clearly identified entry on the same or continuation sheets.

[B] Enter "100" for a 100 cm^2 wipe or "300" for a 300 cm^2 wipe.

[C] Net response in each channel in same units as recorded above.

[D] If primary channel response is greater than that expected for 1 RCL, enter the multiple of the RCL.

Survey Date	[A] Object or Location	[B] Area (cm^2)	[C] Net Channel Response **[1]**	**[2]**	**[3]**	[D] Multiple of RCL	Surveyed By

ALL SURVEY RECORDS MUST BE RETAINED FOR AT LEAST THREE YEARS

RPR 11B. CONTAMINATION SURVEY - WIPE TESTS

Continuation sheet # _____ of record initiated on _____ (Date)

User: _____ Group: _____ Bldg/Room(s): _____

Nuclides used: _____ Critical nuclide: _____ ALI: _____ mCi

Removable contamination limit (RCL): _____ dpm per 100 cm^2 (RPR10)

Survey Date	[A] Object or Location	[B] Area (cm^2)	[C] Net Channel Response [1]	[2]	[3]	[D] Multiple of RCL	Surveyed By

ALL SURVEY RECORDS MUST BE RETAINED FOR AT LEAST THREE YEARS