RI-11 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.

RULES AND REGULATIONS

It is the responsibility of each radiation user to be thoroughly familiar with the University's ***Radiation Control Manual*** and the Radiation Instructions and Forms (RI's and RF'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 principal 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 RCO.

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 action level and any shielding that may be required. See "RADIONUCLIDE DATA" (RI-10).

2 following the instructions or procedures provided by the principal user, the RCO and provided in the *Radiation Control Manual.*

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

4 providing a urine sample, or obtaining a thyroid count, at intervals specified by the RCO. See "BIOASSAYS FOR INTERNAL RADIOACTIVITY" (RI-12).

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

The principal user 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 radioactive materials are secured against theft, misuse and access by unauthorized personnel.

4 radioactive wastes are segregated properly and placed in appropriate containers. Containers are to be provided by the RCO; labels are available from the RCO. Follow the instructions in "RADIOISOTOPE ACQUISITION AND DISPOSITION" (RI-13).

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

6 regular exposure and contamination surveys are performed and recorded.

7 the RCO is notified promptly of any accident or abnormal incident involving radioactive materials.

8 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 1 ALI 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 principal user or another individual specifically designated to be responsible for emergencies.

A "NOTICE TO WORKERS", provided by the Colorado Department of Public Health and Environment and available from the RCO, shall be posted at the entrance 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 RCO.**

RADIATION SURVEY INSTRUMENTS

The principal 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, (^{125}I, ^{51}Cr, ^{99m}Tc, etc.) a thin-crystal scintillation detector, also with audible response, is preferred. For x-ray units, accelerators, and sealed sources, dose rate meters are preferred. Every laboratory is required to have or have immediate access to a backup meter for emergency situations.

The user must know the conversion factor for each survey instrument and record it with all survey results. **The conversion factor is the conversion (usually cpm or cps) from a ^{137}Cs source to which the instrument responds under conditions of normal use; e.g. counts per minute, cpm/(mR/h).** If the instrument has been calibrated for beta contamination surveys, an estimate of the activity per unit area can also be included. The beta efficiency can be used to calculate the estimated dpm/cm^2 for wipes or the estimated activity over an area surveyed. To calculate the dpm/cm^2 on a wipe, use the following equation:

$$\frac{dpm}{cm^2} = \frac{cpm}{eff\,(cpm/dpm) * area(cm^2)}$$

where:
cpm = the counts per minute or counts per second from the survey instrument
eff = the beta efficiency given on the side of the meter
area = the area that was wiped in cm^2

To estimate the activity over an area surveyed, use the following equation:

$$= \frac{cpm}{eff\,(cpm/dpm) * 2.22x10^6\,(dpm/microcurie)} * area(cm^2)$$

where:
cpm = the maximum counts per minute or counts per second from the survey instrument
eff = the beta efficiency given on the side of the meter
area = the area (cm^2) that was surveyed and is above background

The reporting forms attached to this procedure include provisions for recording all pertinent instrument data.

In laboratories where ***only*** tritium (^{3}H) is used, direct surveys are not appropriate and all contamination surveys shall be made by means of wipe tests and subsequent counting on a liquid scintillation detector.

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 RCO 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", 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. 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 conversion factors 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 the RCO 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 the RCO before being put back into use.

EXTERNAL EXPOSURE CONTROL

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 photons 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:

$$D = A*X*T(1/d^2), \text{ where:}$$

D = estimated dose (millirem/quarter)
A = activity handled (millicuries)
X= external dose-rate constant
(mrem/hr at 1 m from 1 mCi) (see RI-10)
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. ^{32}P, may be extremely high at close range. For example, the contact dose rate from 1 mCi of ^{32}P 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 ^{32}P 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 ^{32}P, 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 ^{32}P 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 ^{32}P 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 RCO.

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, make-up application and smoking** in radionuclide handling areas and by careful attention to personal hygiene.

Gloves, lab coats, or other protective clothing that completely cover the legs and feet, should be available and worn to prevent contamination of skin and personal clothing. **Lab coats and gloves should not be worn outside of radionuclide**

handling areas. Sandals or other open-toed shoes and short or short skirts are not acceptable for work with radionuclides.

Work, storage and waste areas should be provided with secondary containers and covered with absorbent paper. Plastic trays and dishpans are suitable for use as secondary containers if they have raised edges. 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 airflow. 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 labeled when the airflow rate was measured. The average face velocity should be in the range of 80 to 150 fpm. If the desired velocity cannot be maintained, the user must make arrangements for repairs or modifications.

In emergency situations, filtered or supplied-air respirators are used to prevent inhalation of contaminants. Whenever the probability of airborne contamination is significant, the RCO 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. See the Radiation Control Manual, Emergency Procedures section.

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. An evaluation of the radiation protection status of each radioisotope laboratory, including a contamination survey, will also be performed by the RCO at least once a year but are routinely performed twice each year.

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 in use at any time, expressed in ALI's. For sealed or nondispersible forms of

radioisotopes, the laboratory shall be surveyed at least semi-annually, regardless of the quantity on hand.

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.

Measurements of contamination by direct detection, and wipe tests 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 l00 to 300 cm^2 should be 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 in emergencies, but the wipe filter should be analyzed with a liquid scintillation counter for routine surveys.

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.

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" (RF-11A). Indicate the calibration date and the calibration factor. Calculate the background exposure rate expected from the instrument using the calibration factor located on the side of the instrument (Background cpm/Calibration Factor). Calculate the minimum detectable exposure rate (MDER) using the following equation:

$$MDER = Bkgd\ Rate\ (mR/h) + (2.33 + 4.65 * (Bkgd\ Rate\ (mR/h))^{1/2})$$

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 at one detector width per second that might be contaminated, holding the detector 1-2 cm from the surface. Record the highest net response for each object or location surveyed.

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. Count the wipe in a liquid scintillation counter and print out the results to attach to the wipe test form.

6 If contamination from low-energy beta emitters, e.g. ^{14}C, ^{35}S, 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 "RADIATION CONTAMINATION SURVEY FORM – PORTABLE INSTRUMENT AND WIPE TESTS" form (RF-11A), record the data identifying the counting instrument, the channels (if appropriate) the count time and the units of readout. The action level is calculated by:

$$Action\ Level = Bkgd\ Rate\ (dpm, cpm, etc.) + (2.33 + 4.65 * (Bkgd\ Rate\ (dpm, cpm, etc.))^{1/2})$$

or using the upper control limit (UCL) from the instrument QA/QC (see RI-57).

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" (RI-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 RCO and the appropriate licensing agency. Recommended forms (RF-11A) 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. Form RF-11B is attached to this procedure for recording personnel surveys.

SPILL KITS AND SPILL CLEANUP

Spill Kit Material:

- Absorbent
  - Powder
  - Pads
  - Neutralizer
- Barriers
  - "CAUTION" Tape
  - Rope
  - Signs
  - PPE
  - Gloves
  - Lab Coat / Apron / Booties
  - Eye Wear
  - Respiratory Protection if Necessary
- Markers
  - Sharpie
  - Grease Pencil
  - Tape

Clean-Up Supplies

- Small Brush and Dustpan
- Detergent Solution
- Scrub Pad
- Paper Towels

Waste Containers
- Clear Plastic Bags of Assorted Sizes
- Sealant for Bags

Wipe Test Supplies
- Wipe Test Filters
- Containers for Filters
  - Envelopes
  - Planchets
  - Vials
- Wipe Test Forms
- Markers for Containers and Forms

Procedures for a spill cleanup are as follows:

1. ***Determine Spill Confinement*** - If the exposure rate is <50 mR/h, determine if the radioactive material has the possibility of escaping your control. Will it flow down a drain or crack? Will it volatilize and escape to the atmosphere? Will it blow away? Do not enter an area where radioactive vapors, gas or mists may be present. Call the RCO and restrict access to the area.
2. ***Determine Exposure Rate*** - Using an appropriate survey meter, determine if the unshielded waste is producing an elevated radiation field. If the exposure rate is >50 mR/h, evacuate immediately and contact the RCO.
3. ***Apply Absorbent (if necessary)*** - If the spill may become unconfined, quickly apply absorbent. Cover small spills with paper towels or dike larger spills with absorbent powder working the powder from the edge of the spill to the center of the spill. NOTE that some liquids may react with absorbents. You may have to use a neutralizing absorbent. Powders or pads may prevent some liquids from volatilizing. Cover volatile liquids with plastic. Do not contaminate yourself while containing the spill.
4. ***Restrict Access to the Spill*** - Erect barriers using chairs, barrier tape, etc. to restrict access to the area. Post signs if necessary. You must prevent others from tracking through the contaminated area.
5. ***Don PPE*** - Don personal protective equipment necessary to clean up the spill safely. Erect shielding to protect your head and body while cleaning the spill. If fumes, gasses or strong odors are present, evacuate the area and call the CSU police and the RCO for assistance.
6. ***Mark the Area of the Spill*** - If you have decided to clean the spill yourself, mark the obvious area of contamination. Use tape, sharpies, etc. to clearly define the contamination zone. Use a survey meter (if possible) to locate hot spots. Mark these as well.
7. ***Clean up Spill*** - Carefully sweep up absorbent into a dustpan or pick up paper towel(s) and transfer the debris into a plastic bag. Place absorbent pads into the bag. Carefully check for glass. Apply a disinfectant solution if the spill contained biohazardous material. Allow it to soak for 20 minutes. Apply a small amount of

detergent solution and clean the contaminated area. Do not spread the contamination. Place all scrub pads, paper towels, etc. in the waste bag. Use a survey meter to monitor the progress of the clean up process.

8. ***Wipe Test*** - Don clean gloves and perform a wipe test. Place the wipe containers in secondary containment that will not be contaminated.
9. ***Manage Clean Up of Waste*** - Carefully remove your PPE and dispose of it in the waste bag. Seal the bag with tape and leave it in the restricted area. Do not remove anything from the area until the wipe results are complete.
10. ***Personal Exit Survey*** - Survey yourself carefully. Remove any contaminated clothing and survey your skin. If skin contamination is evident, start decontamination procedures immediately by washing with detergent and large volumes of water. Contact the RCO for any case of skin contamination.
11. ***Evaluate the Wipe Test*** - Determine if the cleanup effort was successful. Are there any spots with removable activity? If so, contact the RCO for advise / assistance to complete the decontamination. If the wipes were not significantly different than background, perform a final surface survey with an appropriate survey instrument to determine the level of unremovable radioactivity. Contact the RCO in any case where there is unremovable activity.

RF-11A RADIATION CONTAMINATION SURVEY FORM – PORTABLE INSTRUMENT AND WIPE TESTS

Page 1 of _____

Principal User _____ Lab Location _____ Date _____

Surveyed By _____

Nuclides Used _____

Portable Instrument		**Wipe Test Counting Instrument**	
Make, Model, Serial no.		Make, Model, Serial No.	
Background	See Item # 1	Background	See data sheets
Efficiencies	P-32____ C-14____ P-33____ Other_____	Efficiencies	P-32____ C-14____ P-33____ Other_____
Calibration Factor		Data printout sheets attached	
Action Level			

Action Level = (Background+(2.33+4.65*Background$^{1/2}$)) or UCL from Instrument QA/QC

Item #	Item or location (300 cm^2 unless otherwise indicated)	Units ( )	Check if above action level
1	Blank, Background		
2			
3			
4			
5			
6			
7			
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25			
26			

RF-11A Radiation Contamination Survey Form – Portable Instrument and Wipe Tests Continued

Principal User _____ Lab Location _____ Date _____

Page 2 of _____

Item #	Item or location (300 cm^2 unless otherwise indicated)	Units ( )	Check if above action level
27			
28			
29			
30			
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RF-11A Radiation Contamination Survey Form – Portable Instrument and Wipe Tests Continued

Principal User _____ Lab Location _____ Date _____

Page __ of ____

Item #	Item or location (300 cm^2 unless otherwise indicated)	Units ( )	Check if above action level

RF-11B Personal Surveys

(Place a check mark under your name or location surveyed)

Name of Individual or Location of Survey

Date														

RF-11B Personal Surveys

(Place a check mark under your name or location surveyed)

Name of Individual or Location of Survey

Date					

Date					

RF-11B Personal Surveys

(Place a check mark under your name or location surveyed)

Name of Individual or Location of Survey

Date			

Date			

Date			