HANDBOOK FOR SAFE USE OF RADIOISOTOPES

The Office of Environment, Health & Safety, Radiation Safety team worked with several labs to prepare this handbook of recommendations for the safe use of radioisotopes. This guide follows the basic regulations found in the Radiation Safety Manual and precautions specified on individual Radiation Use Authorizations. These recommendations are of a general nature and may not apply to your particular protocol(s). Contact Radiation Safety for advice regarding a specific technique. General radioisotope use recommendations are discussed first, followed by hazards information about specific isotopes. Our experience has shown that there is considerable reduction in area contamination and personnel exposure when these basic precautions are used.

General bench work

- Locate radioisotope work areas away from heavy traffic and doorways to reduce the severity of contamination spread should a spill occur.
- Clear an ample bench area of unnecessary items and cover it with an absorbent material with impervious backing, such as Kimpak. Tape the covering down and label it as a radioactive work area. Do not use paper/flammables if there is a concern for fire , you may wish to use non-flammable trays or no covering. If you have questions, call Radiation Safety.
- Keep all equipment associated with the radioactive materials in this defined and labeled space.
- Label all radioisotope containers and contaminated equipment.
- Keep any volume of radioactive liquid that would not be contained by the bench covering in trays or other secondary containers.
- If necessary, provide sufficient shielding to reduce radiation fields.

Containment of radioactive materials

- Use proper containment for volatile or dispersible materials.
- If volatile or dispersible radioactive materials (especially if high levels) are used there maybe a potential for an airborne hazard from dust or vapor. Some containment may be required. Partial containment is offered by the use of chemical fume hoods. Biological cabinets, glove boxes and other specialized devices are available commercially. Radiation Safety can provide information about applicability and procurement of containments.
- All systems used for radioisotope work requiring enclosures should be tested and approved before such use, and semi-annually thereafter.
- The RUA will usually indicate if a fume hood or other containment is required.

Preparation for the use of radioactive materials

Equipment

- Review the procedure ahead, preparing a list of all materials that might possibly be required.
- Assemble all items needed. If you have everything you will not need to leave the process unattended while you get additional equipment.
- A dry run (no radioactive materials) using the equipment is usually a good idea.

Emergency Supplies

- Try and foresee what problems might occur, including spills.
- Store the appropriate materials that may be needed close to the work area. Some examples would be extra gloves and absorbent covering, wipes, paper towels, plastic bags, forceps, and decontamination solution.
- If a spill can be contained immediately, contamination spread and personnel contamination can be avoided or minimized.

Protective Clothing

- Lab coats, gloves, closed-toe shoes, coverings for the legs, and safety glasses are required when you are handling unsealed radioisotopes.
- Have enough gloves for frequent changes.
- Information on more specialized protective equipment is available from Radiation Safety..

External Dosimetry

- When gamma or higher-energy beta emitters are used, radiation dosimetry may be required.
- Depending on the isotope and amounts to be handled, TLD finger dosimeters and/or whole body badges will be assigned.
- The RUA will indicate what, if any, dosimetry is required.
- Dosimeters must be worn whenever handling the material for which they are assigned.
- Store dosimeters away from radioactive materials and heat.

Instrumentation

- Use of radioisotopes other than H-3 may require an appropriate radiation survey meter.
- Minimum survey meter requirements are indicated on your RUA.

Radioactive Waste

- Place adequate waste receptacles (appropriately labeled) on the work surfaces so waste may be contained immediately after it is produced.
- For dry waste, a plastic bag in a can or Plexiglas box on the work bench may be used. This avoids transfers of contaminated items to the waste area during the procedure.
- Liquid waste containers may also be kept on the bench in secondary containers (such as a 1 gallon bottle in a plastic bag inside a paint can) lined with plastic bags.
- As appropriate, shield the waste receptacles for all isotopes except tritium.
- Do not allow wastes to accumulate in the work area.

Dry runs

- Before performing a new procedure with radioisotopes, it is sometimes helpful to make a dry run without radioactivity, or at reduced levels.
- In some cases colored water may be added to simulate the radioisotope. This will identify exactly which materials and methods are needed, and space and time requirements.
- Dry runs may give you an indication of the most likely routes of exposure or contamination and adjustments made to reduce the hazard.

Handling Procedures

Opening shipments

- Usually, the greatest amount of radioactive material is handled when the isotope stock bottle is opened. If the material is such that there is a possible pressure build-up during shipment or storage, the container should be opened in an appropriate containment.
- A fume hood is a good place to open packages.
- Always assume the outside of the primary container (the vial) is **contaminated and handle with gloves**.

Direct handling of radioactive materials

- The greatest source of **inadvertent contamination** is caused by **contact with contaminated work gloves**. Nearly all isotope work will involve some direct handling of open isotope containers. Whenever this occurs, assume your gloves are contaminated.
- Change gloves if a”clean” item is to be handled. Check your gloves/lab coat often (with a survey meter, except for H-3).
- **If you need to wear the gloves away from the work area be aware of the potential for contamination.**
- A dry run may show when gloves should be changed.
- Cap solutions that are not to be used immediately.
- **Do not pipette radioactive material by any mouth procedure.**

Remote handling of radioactive materials

- Some isotopes may present an external exposure hazard.
- Some remote manipulation may be necessary.
- Use of tongs, forceps, pliers, etc., may lower radiation dose.
- Metal implements should be rubber-tipped for a more secure grip.
- If you use an unfamiliar technique, it should first be practiced with low-hazard materials or a dry run.
- Handling tools are likely to become contaminated and should be checked and cleaned as needed.
- These tools need to be properly labeled.

Transferring radioactive materials **off** campus

- Contact Radiation Safety at least 48 hours prior to shipment. Radiation Safety will:
  a) help you package the materials.
  b) verify that the shipment is allowed (to new location).
  c) take care of the paperwork.
  d) help ship and track the shipment.
  e) help resolve shipping problems (especially if the materials are being shipped out of the United States.

Transferring radioactive materials **on** campus

- Contact Radiation Safety before transferring radioactive materials between RUAs.
- When making liquid transfers, use double containment to prevent spills.
- For large volumes of radioactive solution or waste, a tray or tub should be used so all the liquid can be contained in case of a spill.
- When moving an isotope solution away from the bench, secondary containment is almost always needed.
- Use rigid, covered unbreakable carriers, if isotopes are to be transferred through public use areas (such as hallways).

Self-monitoring

- When working with isotopes (other than H-3), you need to have a portable survey meter on hand to monitor exposure levels and/or check for contamination.
- Use a thin-window GM detector and survey meter for work with beta emitters (including C-14 and S-35, but excluding H-3).
- Gamma emitters (such as I-125) require the use of a gamma specific scintillation detector and survey meter.
- Your RUA will specify the minimum self monitoring and documentation requirements.

- Keep documentation of your self surveys.
- Link your survey data to a survey map by means of numbers or letters, so that areas found to be contaminated can be identified.
- Keep survey records indefinitely.

Survey meters

- Do not use a survey meter to monitor for tritium , use swipes and a Liquid Scintillation Counter (LSC).
- Use a GM meter to determine the location and gross level of contamination.
- Position the probe face 1 to 2 cm. above the surface to be surveyed.
- When surveying, slowly "paint" the area, listen for changes in the click rate.
- In general, to check for contamination, the meter needs to be shielded from background radiation sources.
- Bench or floor surfaces should be checked by direct surveys and by using wipes and monitoring the wipes.

Wipe Monitoring

- This method should be used with all radioisotopes.
- Wipes and LSC analysis are the only method to monitor for H-3.
- Wipes are the only reliable method to use to determine how much contamination is present.
- Express contamination as counts per minute (cpm) per 100 square centimeters of surface (xxx cpm/100 sq. cm. of surface).
- The method involves wiping the surface with an absorbent medium (such as paper wipes) and then counting the wipes by LSC.
- Count an uncontaminated wipe as a background or comparison control.
- Suggested areas to be examined: floor in front of the work area, equipment (heaters, stirrers, tubing), any items handled with work gloves during the experiment (faucet handles, drawer handles, pipetters), and pinch points on floors (doorways, etc.).
- If you find extensive or high-level surface contamination call Radiation Safety.

Clean-Up

- All items involved in the experiment must be surveyed, cleaned, and/or properly stored or disposed.
- Rinse reusable contaminated glassware twice (dispose into a properly marked sanitary sewer disposal sink) before cleaning.
- Do not let potentially contaminated items accumulate in the work area/sink.

- Clean or blot surface contamination (bench or floor) by:
  a) Rub alternately with a wet paper towel with cleaning solution.
  b) then rub with a dry one.
  c) Start in least contaminated area.
  d) Work to most contaminated.
  e) Discard the towels into a radioactive waste container after each application.
  If possible, one sink should be designated and labeled for radioisotope clean-up purposes and all items which might be slightly contaminated should be cleaned there.

Disposal of radioactive waste

- Radioactive materials must be disposed in accordance with the requirements of the campus radioactive material license and Title 17. Referencing State regulation is not a lot of help to guide you on proper disposal; therefore, we have provided detail in Section K of the Radiation Safety Logbook. Section K of the Logbook is updated as needed and the most current copy is found in the Radiation Safety section of the EH&S web site.
- Inappropriate disposal (such as to building trash) can result in **significant expenditure** to recover, regulatory action, potential criminal liability, and undesirable publicity.
- Monitor all items and dispose of all contaminated (or potentially contaminated with H-3) material as radioactive waste.
- Put solid waste in designated and labeled containers.
- Do not place liquids in the solid waste containers.
- Syringes and other sharp objects must be placed in appropriate infectious waste and sharps containers.
- Liquid scintillation vials are disposed into designated containers.
- Animal and biological tissues are normally segregated from other wastes, labeled, and kept frozen until picked up.
- Waste transported out of the laboratory must be properly contained.
- Liquid waste bottles must be labeled, bagged, and carried in secondary containment.
- Solid wastes must be double bagged. All wastes must be documented as to date, RUA, radioisotope, and activity.
- Once materials such as radioactive shipping containers have been emptied, surveyed and verified to be uncontaminated, deface or remove the radioactive labeling and markings. The container can then be disposed of as trash or recycled as appropriate.
- Rad labels, labeled containers, or rad labeling tape, if found outside of the controlled area or the facility, can result in significant expenditure to recover, regulatory action, and undesirable publicity.

- All radwaste forms (solid, liquid, LSC vials, animals) must be segregated by isotope. Call Radiation Safety for information on when commingling is allowed.

Storage and security of radioactive materials

- Storage containers and enclosures must be properly labeled.
- All vessels or containers must have secondary containment.
- Normally, refrigerators or other storage containers should be located in the laboratory.
- Do not store radioactive materials with or near food.
- Many types of containers (such as plastic) are permeable to certain compounds, especially H-3 labeled materials. This leakage has resulted in H-3 contaminated freezer ice. These compounds should be stored in rigid secondary containment such as metal.
- Storage areas must be shielded to less than 2 millirem per hour at contact with the outer surface (of the shield).
- Laboratories with radioisotopes must be locked when unattended.
- Challenge anyone who is in the lab that you do not know. Report problems to UCPD.
- If a person identifies themselves as an inspector, verify their credentials and call Radiation Safety.
- Report any radioactive materials that may be lost, stolen, or misused. Report these problems to Radiation Safety as soon as they are suspected.
- Fire regulations require that lab doors be closed.

Control of airborne radioactive materials

If there is a possibility of your radioactive materials becoming airborne the work must be done in a properly functioning fume hood or equivalent approved enclosure. Using a fume hood effectively:

- Never remove sashes or alter a hood.
- Always check with a piece of tissue to see if the hood is operating prior to use.
- Remove all unnecessary items from the hood to prevent their contamination.
- Cover stationary objects that will not be used.
- Keep the materials in use away from the sash openings.
- Always wear a lab coat, gloves and safety glasses (further protection is available for arms and face).
- Never put your head inside the plane of the hood opening.
- You may want to work around a sash or shield or do some manipulations inside a plastic bag in the hood.
- Keep volatile wastes in the hood. Close, mark and bag the container before removal from the hood.

Control of radioactive contamination

Good lab techniques can prevent personnel, equipment, and facilities from becoming contaminated. Consider the following:

Personal Protective Equipment (PPE)

PPE is used to prevent contamination of skin or clothing. PPE is required if there is a possibility of contamination. PPE includes:

- Labcoat - with sleeves long enough to cover the arms to the wrists, and long enough to cover the torso to the thighs. Wear with the closures fastened.
- Eye protection , required for all lab work.
- Closed-toe shoes - worn to protect the feet from splashes.
- leg covering - worn to protect the legs from splashes.
- Disposable gloves - worn to protect the skin of the hands and wrists from contamination. Gloves are most effective if two pairs are worn at a time, with the outer pair changed frequently.

Bench coverings

- Bench coverings are used to prevent contamination of bench and hood surfaces.
- Plastic backed disposable paper , this paper can be taped in place with the plastic side down. Replace these coverings when damaged (worn, soiled, or torn) or contaminated.
- Containment trays - these shallow trays are useful if spilled materials must be recovered for some reason. Trays are available with disposable plastic liners to ease decontamination.

Double containment methods

Use secondary containers of sufficient volume to contain all of the liquid should a spill occur.

- Liquid waste storage cans , these cans are used to store liquid radwaste bottles. Cans are available from the campus storehouse.
- Transport containers , these are usually a deep plastic tray with a tight fitting lid used to double contain RAM being transported between labs.

Use of disposable materials

- It is preferable to use disposable plastic pipette tips, petri dishes, centrifuge tubes, etc.

Appropriate handling tools

- These tools reduce hand contamination and may reduce extremity dose. These tools include: tweezers, forceps, tongs, and shielded containers.

Preventing internal contamination

- Do not eat, drink, or use cosmetics in radioactive materials use areas.
- Do not store food or drinks in refrigerators or freezers used for radioactive materials.
- Separate food areas at least 1 meter from areas of RAM use or storage.
- If possible, these areas should be separated by physical barriers.

Marking and labeling

- This is the single most important contamination control measure. ALL RAM USE AREAS, EQUIPMENT, AND STORAGE CONTAINERS MUST BE MARKED WITH THE RADIATION TRIFOIL SYMBOL.
- Not marking RAM with the trifoil symbol is the most common cause of the spread of contamination.
- Details on labeling are found in the Radiation Safety Logbook

Minimization of Radioactive Waste

Radioactive waste is very expensive to dispose of. In addition, the more waste is generated the more people must be placed at risk to process it.

- Do not use more radioactive materials than needed.
- Do not use more equipment than is needed.
- Survey materials that you are planning to dispose of as radioactive waste. If the materials are not contaminated, remove any labels and dispose of as building waste, sharps waste, or recycle, as appropriate.
- Minimize the generation of mixed waste. Mixed waste is waste that contains both a radioactive component and a hazardous material component.
- Maximize the use of sink disposal to dispose of liquid wastes.
- Do not mix short half-life waste (such as P-32, P-33, S-35, I-125, etc.) with long half-life waste (H-3, C-14, etc.).
- The better you control contamination the less waste will be generated.
- If you have a choice, use the shortest half-life isotope available.
- RS is available in the lab at the time they perform surveys. Ask them about waste minimization.
- Call Radiation Safety and ask them about waste minimization.

Hazard information for specific radioactive materials

The following are specifics related to hazards for the isotopes most commonly used on campus.

H-3 (tritium)

- PHYSICAL HALF-LIFE (T1/2) - 12.32 Years.
- LOW ENERGY BETA EMITTER - 18.6 KeV (max.) - 5.7 KeV (avg.).
- SHIELDING - No shielding needed.
- RANGE IN AIR - 0.6 centimeter.
- RANGE IN WATER OR TISSUE - <0.006 centimeter.
- EXTERNAL DOSIMETRY - None.
- MONITORING METHOD - Surface wipes analyzed by liquid scintillation.
- EFFECTIVE HALF-LIFE IN HUMANS- At least 10 to 12 days. May be MUCH greater for DNA precursors or chemical forms that are incorporated or retained in the body.
- BODY ORGAN THAT RECEIVES THE MOST DOSE - Whole body.
- BIOASSAY METHOD AND DOSE FROM INTAKE - Urinanalysis by liquid scintillation counting. Internal dose from a single intake of 1 microcurie is 0.06 millirem. Bioassay frequency, if any, will be indicated on your RUA.
- VOLATILITY - Tritiated water and tritium borohydrides are very volatile. This is also the case with pressurized tritium gas.
- STORAGE - Tritiated compounds are somewhat unstable, and are often stored at low temperatures. Even when stored in tight containers, tritium will exchange readily with water in ice or condensation. Storing tritiated compounds in desiccators when in freezers and refrigerators will help to prevent the spread of contamination.

Special Handling Procedures for H-3

- Due to the very low energy of the H-3 betas, external dose rates are negligible. Many of the commonly used tritiated compounds are volatile and readily taken up by the body via ingestion, inhalation, or skin absorption. NOTE: Poor practices can lead to substantial exposures.
- Hood use is usually required for work with amounts larger than 10 millicuries, but the fume hood should be used as much as possible for any tritium work.
- Some procedures which produce high activity volatiles must be done in a closed or trapped system.
- The tritium in many compounds, including water, tends to exchange with hydrogen in surrounding surfaces. Migration through plastic is to be expected. Surgical gloves normally used for isotope work will protect the hands for only a few minutes after they are contaminated. Once the tritium has permeated the gloves, the perspiration inside results in skin

absorption. It is important to change gloves frequently during an experiment and whenever they may be contaminated.

- Bench and other protective covers must also be discarded as soon as possible due to their limited protective life.
- Tritiated compounds should be stored in tightly closed glass or metal with substantial stoppers or lids, preferably in secondary containment.
- Freezer ice absorbs the contamination readily and should be checked periodically by liquid scintillation counting.
- Many procedures use labeled nucleic acid precursors, such as tritiated thymidine. This material is preferentially incorporated into cell nuclei. This can result in a greater per microcurie dose.
- Hydrides, such as borohydride compounds in powder form, may also be used. Activities may be as high as 1,000 millicuries per preparation. This material presents special hazards since it is a dispersible solid and also may produce tritiated gases. Pressures often build up during storage or transport due to decomposition into free hydrogen. When a vial or ampoule is opened some of the fine powder will escape, sometimes causing severe contamination. Work with these materials must be done in the hood. You may want to open the container and transfer solids inside a plastic bag. Discard the bag, which should contain any released powder, after the material is in solution or capped. Assume the containers involved are contaminated on the outside. If possible, put the material into solution in the original container, this avoids transferring the solid. Storage solutions must be of basic pH to prevent hydrogen production.
- Any reaction which may produce gases must be done in the hood.
- Electron capture detectors used in gas chromatographs may contain tritium gas absorbed on Ti or Sc metal foils. These foils contain activities of 100 to 1000 millicuries and the high temperature they are subjected to in use tends to drive off some of the tritium and result in area contamination. Temperature limits should be: 225 degrees C for the Ti foils and 325 degrees C for the Sc foils. Chromatographs containing H-3 foil electron capture detectors must be provided with automatic temperature control and must be vented into an appropriate exhaust system when in use. If a foil is removed from the detector, it must be handled as unsealed radioactive material. Work with the foil must be done in a hood and precautions must be taken to prevent contamination.
- Vacuum Systems: Many experiments require the use of a vacuum line. If the material under partial vacuum contains high activity tritium, some of the isotope will probably be drawn into the system. Use an appropriate trap to protect pumps or the house vacuum line from contamination. Pumps involved in high activity work should be vented into the hood. Check the pump and lines for contamination after use.

- PHYSICAL HALF LIFE (T1/2) - 5730 Years.
- LOW ENERGY BETA EMITTER - 156 KeV (max.) - 49 KeV (avg.).
- SHIELDING - Usually none required.
- RANGE IN AIR - 22 cm.
- EXTERNAL DOSIMETRY - none.
- MONITORING METHODS - GM survey meter (used carefully at very close range) and surface wipes (best analyzed by LSC).
- EFFECTIVE HALF-LIFE IN HUMANS - 40 days in bone and 10 days in the whole body. May be **MUCH**greater for DNA precursors or materials that are incorporated into or retained in the body.
- BODY ORGAN THAT RECEIVES MOST DOSE - Fat/whole body.
- BIOASSAY METHOD AND DOSE FROM INTAKE - Urinalysis by liquid scintillation counting. Internal dose from a single intake of 1 microcurie is 2 millirem.
- VOLATILITY - C-14 compounds are normally not volatile and can be carefully used on the bench top.
- STORAGE - C-14 should always be stored well contained and marked.

Special Handling Procedures for C-14

- External exposure is not significant.
- Avoid skin contact, and protect against ingestion. Some procedures may produce gaseous forms of C-14 (also plant or animal respiration). In these cases, you may need to trap the gas or vent it to a fume hood.
- Surface contamination may be monitored directly with a thin-window GM survey meter. Evaluation of contamination can be done by wipes, counted on a LSC.
- Genetic material precursors: Many procedures use labeled nucleic acid precursors, such as C-14 labeled thymidine. Since this material is preferentially incorporated into cell nuclei, it will result in a per microcurie dose greater than that for other C-14 compounds that are released from the body at a faster rate.

S-35

- PHYSICAL HALF LIFE (T1/2) - 87.4 days.
- LOW ENERGY BETA EMITTER - 167 KeV (max.) - 49 KeV (avg.).
- SHIELDING - Usually none required.
- RANGE IN AIR - 24 cm.
- EXTERNAL DOSIMETRY - none.
- MONITORING METHODS - GM survey meter (used carefully at very close range) and surface wipes (best analyzed by LSC).
- EFFECTIVE HALF-LIFE IN HUMANS , 77 days in the testis. 77 days in bone, 83 days in skin, and 44 days in the whole body. May be **MUCH**

greater for DNA precursors or other materials that are incorporated into or retained in the body.

- BODY ORGAN THAT RECEIVES MOST DOSE - Testis/whole body.
- BIOASSAY METHOD AND DOSE FROM INTAKE - Urinalysis by liquid scintillation counting. Internal dose from a single intake of 1 microcurie is 0.5 millirem.
- VOLATILITY - S-35 compounds are normally not very volatile and can be used on the bench top. Methionine and cysteine labeled with S-35 may lose perhaps 1% of their activity as (sulfur-35 dioxide) in storage. Various lab processes such as incubations may increase the amount of activity being liberated. Vials containing frozen S-35 labeled compounds should be thawed in a properly functioning fume hood.
- STORAGE - Storing in a desiccator with activated charcoal will help to prevent the spread of contamination.

Special Handling Procedures for S-35

- External exposure is not significant. Avoid skin contact, and protect against ingestion.
- Contamination may be monitored directly with a thin-window GM survey meter if the material is on an unshielded surface. More sensitive evaluation of removable contamination can be done with wipes, counted by liquid scintillation.

P-32

- PHYSICAL HALF-LIFE (T1/2) - 14.3 days.
- HIGH ENERGY BETA EMITTER - 1.71 MeV (max.) - 0.690 MeV (avg.).
- SHIELDING - at least 1 cm of Lucite or equivalent. Special shielding may be required to reduce Bremsstrahlung (x-rays) produced in the source container or Lucite.
- RANGE IN AIR - 7.2 meters.
- RANGE IN TISSUE - 1 cm.
- EXTERNAL DOSIMETRY - TLD ring and/or body badge as required by amount. Requirements are found on your RUA.
- MONITORING METHODS - GM survey meter and surface wipes.
- EFFECTIVE HALF-LIFE IN HUMANS - 14.1 days in bone, 13.6 days in the whole body, and 8 days in the liver.
- BODY ORGAN THAT RECEIVES THE MOST DOSE - Bone.
- BIOASSAY METHOD AND DOSE FROM INTAKE - Urinalysis by liquid scintillation counting. Internal dose from a single intake of 1 microcurie is 30 millirem (bone). Bioassay frequency, if any, will be indicated on your RUA.

- VOLATILITY - P-32 compounds are not normally volatile and can be used on the bench top, if proper precautions are taken.
- STORAGE - P-32 should always be stored properly shielded and marked.
- EXTERNAL DOSE RATE:
  1 millicurie in air at one centimeter is 200 Rem/hr. (20 at 10 cm).
  1 millicurie in 1 milliliter of water at the surface of a vial is 1 Rem/hr.

- Dry P-32 can have a dose rate of up to 4,000 times that in solution.
- NOTE: The high energy beta emission from P-32 will interact with dense materials like lead to produce Bremsstrahlung (x-rays).

Special Handling Precautions for P-32

- Due to the high, unshielded dose rates, manipulations of open P-32 solution containers must be kept to a minimum.
- Take care to reduce the possibility of skin contact.
- Millicurie amounts present a high skin exposure hazard at short range.
- Hands are likely to receive high doses when directly handling normal lab containers.
- Remote manipulation can decrease dose rate.
- Handle primary containers with tongs, forceps, or pliers.
- For transfers, use a system which keeps the liquid level well away from the hand.
- **Any** process that uses dry P-32 (such as paper chromatography, paper electrophoresis, or blotting on filters) should be done with great care and frequent monitoring of exposure levels.
- For most P-32 work, hand dose will be 10 - 100 times greater than body dose. Remember that 1 centimeter of tissue will totally absorb P-32 betas, so wearing a TLD ring on the wrong side of the hand will cause great error in dose assessment.

Shielding P-32

- Beta radiation is easily shielded.
- When beta particles interact with high molecular weight materials Bremsstrahlung (X-rays) are produced. This secondary radiation is much lower in energy and quantity than the primary beta particles but is harder to shield due to its greater penetrating ability. Since Bremsstrahlung production is proportional to the atomic number of the absorber, materials such as Lucite should be used for shielding.
- 0.5” (0.8 cm) of Lucite will adequately shield most of the P-32 radiation.
- Consider shielding in project planning.
- Use of small shielded containers and transfer devices may reduce the need for large inconvenient bench shields.
- Shields must be designed so that the face and eyes are protected.
- The eyes are more radio-sensitive than the skin. Wear safety glasses.

- Radiation Safety can advise on shielding.

I-125

- PHYSICAL HALF-LIFE (T1/2) - 60 days.
- LOW ENERGY GAMMA EMITTER - 32 KeV.
- SHIELDING - at least 0.25 mm of lead or equivalent.
- HALF VALUE LAYER IN AIR - 2.4 meters.
- HALF VALUE LAYER IN TISSUE - 2.6 cm.
- EXTERNAL DOSIMETRY - TLD ring and/or body badge as required by amount. Dosimetry requirements are found on your RUA.
- MONITORING METHODS - NaI detector survey meters and surface wipes (best analyzed by liquid scintillation counting). NOTE: GM survey meters have a low efficiency (less than 1%) for these gammas. GM meters will find only large amounts.
- EFFECTIVE HALF-LIFE IN HUMANS - ~42 days in the thyroid, 11.4 days in bone, and 6.3 days in the kidney, spleen, and testes. May be **MUCH** greater for DNA precursors or other materials that are incorporated into or retained in the body.
- BODY ORGAN THAT RECEIVES THE MOST DOSE - Thyroid.
- BIOASSAY METHOD AND DOSE FROM INTAKE - Direct counting of the thyroid. A single intake of 1 microcurie will result in a 0.8 Rem dose to the thyroid. Bioassay frequency, if any, will be on your RUA.
- VOLATILITY - Many I-125 compounds are volatile (especially NaI). It is recommended that radioiodine work should be performed in a properly functioning fume hood. Store I-125 wastes in the hood. Compounds containing I-125 are less volatile at alkaline pH and at room temperature.
- EXTERNAL DOSE RATE FROM:
- 1 mCi in 1 milliliter of water at the surface of the vial is 400 mrem/hr.
- 1 mCi in 1 milliliter of water is 150 mrem/hr. at 1 centimeter.
- 1 mCi in 1 milliliter of water is 5 mrem/hr. at 10 centimeters.
- STORAGE - Some I-125 compounds may be stored at room temperature. Store in a fume hood. Use adequate shielding.

Special Handling Procedures for I-125

- Because I-125 is a low-energy gamma emitter radiation intensity is inversely proportional to the square of the distance from the material.
- Millicurie amounts present a substantial exposure hazard at short range (1 cm.).
- A reduction of a factor of 100 in exposure rate can be obtained by moving 10 centimeters from the material.
- Use remote handling techniques when handling millicurie amounts.

- Many iodine compounds are slightly volatile and certain reactions release volatile products.
- Once ingested, one-third of the activity is concentrated in the thyroid, the rest rapidly excreted.
- Since low activity intakes cause high thyroid doses, it is essential to minimize the potential for skin exposure, ingestion, and inhalation of radioiodine.
- Keep solutions basic to minimize free iodine release.
- Contact RS immediately if there is any suspicion of a radioiodine release into the laboratory atmosphere.

Shielding

- Very thin sheets of lead or other dense metal are sufficient to shield I-125.
- Two tenth-value layers (0.14 mm of lead) are generally adequate.
- Leaded plastic/glass can shield I-125.

P-33

PHYSICAL HALF-LIFE (T1/2) = 25.4 days

LOW ENERGY BETA EMITTER - 249 KeV (max) - 76 KeV (avg.)

SHIELDING - Usually none required. Working with mCi amounts at short range (less than one foot) may require thin (2 mm) Lucite shielding.

RANGE IN AIR - 46 cm.

DOSIMETRY - None.

MONITORING METHODS - GM survey meter (used carefully at close range) and surface wipes (best analyzed by liquid scintillation counting).

EFFECTIVE HALF-LIFE - 19 days.

CRITICAL ORGAN - Bone.

BIOASSAY METHOD AND DOSE FROM INTAKE - Urinalysis by liquid scintillation counting. Internal dose from a single intake of 1 microcurie is 0.9 mRem. Bioassay frequency will be indicated on your RUA.

VOLATILITY - P-33 compounds are not normally volatile and can be handled on the bench top, if proper precautions are taken.

STORAGE - P-33 should always be stored well contained, and marked.

Special Handling procedures for P-33

External exposure hazards are moderate. Avoid skin contact, and protect against ingestion. Remote handling devices should be used when working with mCi amounts for longer than a few minutes.

Contamination can be monitored directly with a thin window Geiger survey meter if it is deposited on an unshielded surface. More sensitive evaluation of removable contamination can be done with wipes, counted by liquid scintillation.

HAZARDS INFORMATION FOR SELECTED GAMMA EMITTERS

Isotope	Physical Half-Life days	Principal Energy MeV	Inch Lead X10 Dose Reduction	Dose Rate Per mCi Foot in mrem/hr	Critical Organ	Annual Limit on Intake (inhalation) uCi
Cr-51	28	0.3	0.25	0.2	Intestine	50,000
Na-22*	950	0.5 & 1.3	1	12	Whole Body	600
Na-24*	0.625	1.4 & 2.8	2.5	18	G.I. Tract	5,000
I-131*	8	0.36	0.32	2	Thyroid	50
Cs-137*	10,957	0.66	1	3.3	Whole Body	200
Co-57	270	0.12	0.02	0.9	G.I Tract	3,000
Fe-59	45	1.1 & 1.3	1.5	6.4	G.I Tract	500
Mn-54	300	0.84	1	4.7	G.I Tract	900
Se-75	120	0.14 & 0.27	0.2	2	Whole Body	700

* Also emits betas, medium to high energy.

(e) Dose rates decrease in proportion with the square of the distance.

(f) Always handle with remote appliances and use lead shielding for work and storage areas.

(g) Monitor hands, clothing and the work area frequently.

(h) When working with millicurie amounts a lead enclosure should be used to reduce dose rates.

(i) RS can advise on methods of monitoring and reduction of radiation levels.