HEALTH PHYSICS

Emergency Procedures and Levels of Action

AREAS OF RESPONSIBILITY:

1. Personnel Monitoring: Film badges, ring dosimeters, and other types of personnel monitors are available to persons working with radiation sources. Health Physics must maintain permanent dosimetry records on all persons furnished personnel monitors and will require your name, department, birth date, and social security number for these records. An individual may request a report of his acquired radiation dose from Health Physics.

2. Bioassay Procedures: Bioassays for H-3, I-125, and I-131 are required for personnel working with millicurie activities of these isotopes. The analysis of a possible body burden of these radioisotopes is obtained by urinalysis or gamma counting over the thyroid area. Bioassays for other radioisotopes may be performed when needed.

3. Sealed Source Leak Tests: Sealed radiation sources must be monitored at 3 or 6 month intervals to insure that the integrity of the source containment is maintained. Reports of the leak tests are issued to the source custodians. Sources that are found to be leaking must be withdrawn from service.

4. Laboratory Surveys: Laboratories in which radioactive materials are used or stored are monitored and inspected monthly, quarterly, semi-annually, or at annual intervals by Health Physics personnel. The frequency of the surveys depends on the potential radiation hazards within the laboratory. Reports of the surveys and inspections are issued to the person responsible for the laboratory with comments on items needing improvement.

5. Radioactive Waste Disposal: Radioactive waste must be disposed separate from ordinary waste and cannot be discharged to the sewer. Special receptacles are available for dry and liquid radiation wastes. Radioactive wastes are collected by Health Physics personnel when contacted by the laboratory personnel.

6. X-ray Surveys: X-ray machines and equipment should be monitored each year by Health Physics personnel. Reports of the survey are issued to the person responsible for the equipment.

7. Electron Microscope Surveys: Electron microscopes produce x-rays that may expose the operators if the microscope is not properly constructed and shielded. Electron microscopes are monitored each year and the survey results reported to the person responsible for the equipment.

8. Laser inspection: Lasers and other high intensity light sources may produce serious eye damage if used improperly. Lasers are registered and then inspected each year.

9. Monitoring Incoming Radioactive Packages: Packages containing radioactive materials must be monitored at Health Physics upon arrival on campus and before they are delivered to the user.

10. Survey Instrument Calibration: Radiation calibration sources are available through Health Physics. Health Physics will calibrate survey meters for gamma radiation with these sources. Instrument response to different beta radiation can also be evaluated. Survey instruments should be calibrated at regular intervals.

11. Radiation Safety Records, Authorization, and Licenses: Health Physics maintains all files on radiation safety pertaining to the Missouri S&T program. Personnel dosimetry files, authorizations, surveys, waste disposal, and NRC licenses are available for inspection at the Health Physics office.

12. Emergency Response: Health Physics responds to any suspected radiation emergency at Missouri S&T. Health Physics may be contacted at 341-4240 during working hours and through the University Police 911 nights, weekends, and holidays.

- *Persons working with radiation must be familiar with the regulations, procedures, and responsibilities regarding their work. Information on radioactive material, authorizations, licensure, and radiation safety is available from the Health Physics office located in Environmental Health and Safety at 341-4305.*

CONTENTS

Decay of a Radioisotope

1. From documentation provided by the vendor, determine the original activity at date (and time if given) of reference.

2. Determine the radioactive half-life of the isotope from reference tables.

3. Calculate the time elapsed since the reference date. The time interval must be in the same units as the half-life.

4. Calculate the number, n, of half-lives during the time interval.

   n = Time Interval / Half-life

5. The activity remaining (A) will be the original activity (A_o) times the appropriate factor.

   $A = A_o \, e \wedge (- n*\ln 2)$

   $A = A_o / (2 \wedge n)$

Exposure

Estimate your monthly exposure from a radiation field.

1. Obtain the exposure rate in the work area with your survey meter or from the Health Physics survey report (mrem/hr).
2. Estimate the number of hours or fractions thereof you will be in the work area.
3. Multiply the number of hours by the number of millirem per hour or exposure. This should approximate your exposure for the monitoring period.

   Millirem per hour * hours = millirem

Sample Radiation Calculations

Prefixes:

- milli(m) = 10E-3
- micro(µ) = 10E-6
- nano(n) = 10E-9
- pico(p) = 10E-12

1. Bq = 1 decay / second curie(Ci) = 2.22E12 dpm = 3.7E10 dps
2. millicurie(mCi) = 2.22E9 dpm = 3.7E7 dps
3. microcurie(µCi) = 2.22E6 dpm = 3.7E4 dps
4. picocurie(pCi) = 2.22 dpm

Activity:

Convert counts per minute obtained with the detection instrument to microcuries.

1. Count a standard sample or source of known activity.
2. Count background. If it exceeds 5-10% of standard count rate, correct for background by subtraction.
3. Convert the activity of the standard counted to disintegrations per minute (dpm).
4. Divide the counts per minute (cpm) obtained with the standard sample by the disintegrations per minute (dpm). This gives the efficiency for detection of the isotope with the detection system. (*efficiency, e = cpm / dpm*)
5. To determine the activity of this isotope in a sample of unknown activity counted under similar conditions, divide the cpm obtained with the unknown sample by the efficiency. (*dpm = cpm / e*)
6. Convert the dpm to activity by dividing by 2.22Ex, where x is the appropriate power of ten to yield workable numbers of the curie prefix, e.g., x = 6 for microcuries.

Radionuclide Inventory Control

Investigators authorized to process and use radioactive materials shall, as a condition of the University's NRC licenses, maintain inventory records of the receipt, use, storage, and disposal of all radioactive materials in their possession. These records must be maintained in such a manner that, at any given time, the isotopes and activities may be located and totals readily calculated to assure that the authorization limits have not been exceeded. It is important to note that the material collected as waste and stored for pickup must be included in these totals until removed by Health Physics for disposal.

It is intended that the inventory be as much a service to the investigator as to Health Physics or an NRC compliance inspector without being an undue burden or hindrance.

The minimum requirements for the record are the isotopes, activities, dates relating to the receipt of the material, its total or fraction of use, and its disposal proportioned between liquid, solid, and/or animal wastes. A receipt of material from commercial vendors, Missouri University of Science and Technology Reactor Facility, and/or transfers to and from other University authorized investigators must be included in the log. All shipments of material leaving the University must be monitored and certified by Health Physics before shipment. Radionuclide inventory forms to summarize receipts, transfers, and disposal are available from Health Physics. Health Physics will require that the isotopes and activities present in the waste be identified before the waste will be picked up for disposal.

There are many types and formats of inventory records. Items contained and methods used in some of these formats which may be of interest to other investigators are:

- Routine notations as to dilutions performed listing the isotopes activities, compounds, total volume of dilutant and activity per unit volume.
- Subtraction of the activity from the running total of a stock volume to facilitate inventory control.
- Utilizing separate pages for separate isotopes, compounds, and/or shipments so when an item has been used the sheet is closed out.
- A running total on a per shipment basis lends itself to simple decay corrections if necessary.
- A permanent records book or posting of log sheets of material on hand at a central location provides ready access to the information on materials and activities available for use.

Health Physics can assist in the development of a suitable record system for individual laboratory situations. Also available for use is the RadSafe-25 Radionuclide Inventory Log Sheet.

Radiation Protection and Guidelines

Units:

Roentgen (R) - Exposure unit. One roentgen equals a charge of 2.58E-4 coulombs induced in one kilogram of air.

Gray (Gy) - SI unit of absorbed dose. 1 Gy = 1J/kg = 100 rad

Rad - Absorbed dose unit. One rad equals 100 ergs per gram or 0.01 J/kg absorbed in any material.

Sievert (Sv) - SI unit of dose equivalent. This is a unit of dose appropriately modified to correct for the differences in biological effects of the different types and energies of radiation. 1 Sv = Q * Gy = 100 rem

Rem - Unit of dose equivalent. This is a normalized unit of dose appropriately modified to correct for the differences in biological effects of the different types of radiation.

Activity - The number of nuclear transformations occurring in a given quantity of material per unit time.

Becquerel(Bq) - SI unit of activity. 1 Bq = 1 decay/second.

Curie (Ci) - Activity unit. One curie equals 3.7E10 nuclear disintegrations or transformations per second or 2.22E12 per minute.

Half-life (T½) - The time it takes for a radioactive substance to lose 50% of its activity by decay.

Dose equivalent - The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest.

Deep-dose equivalent - The dose equivalent, for external exposures, at a tissue depth of 1 cm (1000mg / cm^2).

Committed dose equivalent - The dose equivalent to an organ or tissue of reference that will be received from an intake of radioactive material by an individual during a 50-year period following the intake.

Committed effective dose equivalent - The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and committed dose equivalent to each organ or tissue.

Total effective dose equivalent (TEDE) - The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Guidelines Occupational vs. General Population

- The radiation dose limit for the general population is 10% of the radiation dose limit allowed for radiation workers.

- Dose limits for occupational workers is the more limiting of the following:

1. TEDE must not exceed 5 rem a year.
2. The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye must not exceed 50 rem per year (4 rem per month).
3. The dose equivalent to the eye must not exceed 15 rem per year (1.25 rem per month).
4. The dose equivalent to the skin or any extremity (hands and arms below the elbows, feet and legs below the knee) must not exceed 50 rem per year (4 rem per month).
5. The deep-dose equivalent to an embryo/fetus due to the occupational dose to a declared pregnant woman and the dose equivalent to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman must not exceed 0.5 rem for the entire pregnancy under a uniform monthly exposure rate.
6. Anyone under 18 years of age, except declared pregnant women, is limited to 10% of the above values.

External Exposures

External exposure is monitored by film badges and thermoluminescent dosimeters (TLD). Health Physics will contact personnel who receive in excess of 100 millirems TEDE or 50 millirems per month for females younger than 45 years of age. Exposure summaries are provided annually.

Internal Exposures

Health Physics will investigate and take action if a urinanalysis shows a level exceeding 5 microcuries per liter.

Radioiodine

Health Physics will investigate and take action if the thyroid burden exceeds:

For I-125: 0.12 µCi
For I-131: 0.04 µCi

Survey Reports

Data obtained with a G-M survey meter are reported in millirem per hour (mrem/hr). Any locations where exposure levels are greater than 0.05 mrem/hr are noted and reported. Based on a 40-hour work week and 50 work weeks per year, 0.05 mrem/hr would equal 100 mrem/hr.

Data obtained from the swipe contamination survey are reported in picocuries per 100 square centimeters (pCi / 100cm^2). Activities below 100pCi / 100cm^2 will generally not be reported.

RADIATION EMERGENCY PROCEDURES

A. Fire emergencies involving radiation

1. Call university police 911 and give nature and location.
2. Set off fire alarm.
3. Notify all personnel in the area to leave immediately and assemble in a nearby safe area.
4. Use extinguisher if blaze is small.
5. Inform emergency personnel about radioactive materials, where they are stored, being used, present location as well as any precautions to avoid exposure.
6. Follow Paragraph C. (Radiation Safety Procedures)
7. University police should notify the Radiation Safety Officer (RSO) of the incident immediately.

B. Medical emergencies involving radiation

1. Call university police 911 if requested by injured person or if person is unconscious.
2. If the medical Emergency involves a student, work with university police to insure student Health Services is notified.
3. Inform medical personnel that radiation hazard may exist.
4. University police will notify RSO of incident.

C. Radiation safety procedures

1. Evacuate personnel from radiation area.
2. Assemble all personnel in nearby safe area and keep them there until radiation surveys and personnel decontamination are performed by RSO.
3. Prevent spread of contamination from accident site. Use nearest telephone for communications and avoid walking through the building.
4. Close doors and windows and, if convenient, turn off air equipment that might transfer radiation contamination throughout the building.
5. Control access to radiation area and place warning signs indicating radiation and contamination hazards.
6. University police will notify RSO of incident.

7. Decontamination of rooms and building shall only be done under Health Physics supervision.

Emergency Number

Dial 911

LABORATORY RULES FOR RADIATION SAFETY

- Keep laboratory neat and clean and maintain uncluttered work areas.
- Wear protective apparel as required such as gloves, laboratory coats, and goggles.
- Wear a personnel monitoring device if required by Health Physics.
- **Do not eat, smoke, or drink in a radiation laboratory.**
- **Do not store food or beverages in cabinets and refrigerators used for radioisotope storage.**
- Do not pipette radioactive solutions by mouth.
- Use hoods or glove boxes for handling millicurie or higher activities of radioisotopes.
- Label radioisotope containers and post radioactive warning signs in laboratory areas where radioisotopes are used.
- Use shielding to reduce radiation exposures to working personnel and to other persons in the vicinity.
- Store radioactive materials in a secured storage area to alleviate unauthorized or inadvertent use.
- Purchase, store, and use the minimum activity required for any procedure.
- Practice procedures with nonradioactive substances before performing them with radioactive materials.
- Accumulate radioactive waste separate from normal waste in specified radioactive waste receptacles.
- Do not transfer radioactive materials to unauthorized persons.

- Survey laboratory areas, equipment and personnel after every experimental procedure utilizing radioisotopes.

- Maintain written procedures for the laboratory operations and post emergency procedures listing emergency and laboratory personnel and how to contact them.

EHS Director	Health Physicist
Missouri S&T	Missouri S&T
(573)-341-4240	(573)-341-7014

CLEANING MINOR RADIOACTIVE SPILLS

***Note**

This policy applies to spills that are microcurie activities and the contamination is only in a single room. If more than microcurie activities are involved in a spill or if the contamination extends beyond a single room, Health Physics must be contacted immediately to supervise the decontamination effort.

1. Notify persons in the area that a spill has occurred. Do not remove objects or allow people to leave contaminated area until monitored.
2. Absorb spilled material with paper towels or cloth to limit spread of contamination.
3. Clean up the spill, wearing disposable gloves and using paper towels and ordinary cleaning solutions. Start at the least contaminated area and proceed towards the area of greatest contamination.
4. Carefully fold the paper with the clean side out and place in a plastic bag for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag.
5. Survey the area with an appropriate radiation detector survey meter and with swipe tests or other appropriate technique. Check the area around the spill for contamination. Also check hands, clothing, and shoes for contamination.
6. Report the incident to the Radiation Safety Officer (RSO) promptly.
7. Allow no one to return to work in the area unless approved by the RSO.
8. The RSO should follow up on the decontamination activities and document the results.
9. If appropriate, the RSO should determine the cause and take corrective actions if needed, considering bioassays, if there is potential for internal contamination.
10. If necessary, notify NRC.

PROCEDURES FOR RUPTURED OR LOST RADIATION SOURCES

I. Suspected ruptured or leaking radioactive sources

1. Have all personnel leave and close all doors to the possibly contaminated area.
2. Inform the source custodian and Health Physics immediately. Use the nearest phone and restrict contaminated personnel from unnecessary movement through the building.
3. Keep all involved persons assembled in a safe area until checked for contamination. Do not enter the possible contaminated area unless an emergency exists.
4. Suspected ruptured or leaking source must be removed from service by the Health Physicist.

II. In case of lost or misplaced sources

1. Report loss immediately to the source custodian and Health Physics.
2. Request that no wastes or equipment be removed from the building until checked by Health Physics.
3. Begin interviewing all persons who may have used the source to determine the last documented location.

Health Physics	**341-7014**
Source custodians	
____________________	________
____________________	________
____________________	________