

CHAPTER 32 – IONIZING RADIATION

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CHAPTER 32 - IONIZING RADIATION

A. INTRODUCTION

1. This chapter applies to all Smithsonian Institution (SI) facilities, laboratories and museums that possess or use radioactive byproduct material licensed by the U.S. Nuclear Regulatory Commission (NRC), naturally occurring radioactive materials (NORM), and x-ray devices. Materials acquired through a general license may not be subject to all of the provisions of this chapter; however, facilities may be subject to applicable Department of Transportation (DOT) and U.S. Environmental Protection Agency (EPA) regulations.
2. It is the policy of SI that the primary means of controlling potential health hazards from exposure to ionizing radiation is through the implementation of a centralized program that emphasizes employee training and education, and incorporates radiation safety standards into audits, surveys, and inspections. The goal of this policy is to ensure that the possession and use of all sources of ionizing radiation are conducted so that exposures to employees and the general public will be as low as reasonably achievable (ALARA) ([Attachment 1](#)).
3. Affected SI personnel shall develop radiation safety procedures unique to the facility; however, such procedures will not exclude the requirements of this Chapter. Additional requirements not specifically identified in this Chapter may be developed to meet particular project or research applications. Program- and research-specific procedures shall become a mandatory part of each SI Facility-Specific Radiation Safety Program.
4. Research projects in which radioactive materials are used in foreign countries outside the jurisdiction of the United States Government shall conform to the laws and regulations of the host country. A written Project-Specific Radiation Safety Program shall adhere to the general requirements of the SI Program, and strictly conform to the rules of the host country. All waste generated shall be disposed of in a manner acceptable to the host country or returned to the United States. In the event neither waste disposal approach is possible, waste shall be stored on-site or in an approved facility, until an acceptable means of disposal or release is available. Where possible, the guidelines and recommendations of professional international organizations shall be followed.

B. CHAPTER-SPECIFIC ROLES AND RESPONSIBILITIES

- 1. Facility Radiation Safety Coordinators.** Facility Radiation Safety Coordinators (RSCs) shall be designated by facility management to oversee the possession, use and disposal of sources of ionizing radiation within their facilities. Each RSC shall coordinate the activities involving sources of ionizing radiation between Safety Coordinator, supervisors, individual users and OSHEM. The facility RSC shall:
 - a. Ensure that all affected staff, to include maintenance and housekeeping staff, are informed about the presence of radioactive materials in designated work areas and receive training commensurate with the type of work being performed in these areas.
 - b. Ensure that the possession and use of all sources of ionizing radiation within their facilities meet applicable regulatory and SI requirements. Coordinate the review and approval of new protocols that use radioactive materials.
 - c. Maintain a current inventory of licensed byproduct radioactive materials and other sources of ionizing radiation.
 - d. Maintain an inventory of radioactive waste(s) generated at their specific facility.
 - e. Provide advance notification to OSHEM for planned changes to inventories of radioactive materials and x-ray devices, as well as transfers of sources of ionizing radiation between facilities and for new projects.
 - f. Ensure routine health physics surveys are conducted and documented in laboratories and other areas where radioactive materials are used or stored.
 - g. Ensure procedures for receipt and shipping of all radioactive materials meet applicable requirements, including security, packaging, transport, and labeling and surveys.
 - h. Develop and coordinate radioactive material waste disposal procedures, including the maintenance of waste storage and disposal records.
 - i. Ensure leak tests are conducted on sealed sources where applicable. Maintain records of all leak tests conducted.
 - j. Supervise decontamination and corrective action for radioactive material spills and incidents.
- 2. Supervisors.** Supervisors shall be responsible for the management and use of sources of ionizing radiation within their areas of responsibility and for activities conducted by individuals working under

their supervision. Supervisors shall:

- a. Develop and implement radiation safety procedures for specific projects/research applications for sources of ionizing radiation.
- b. Ensure workers and associated personnel receive applicable training prior to work or entry into areas that contain sources of ionizing radiation.
- c. Distribute and collect personnel monitoring devices. Supervisors shall notify the RSC when additions or deletions to the dosimetry program are necessary.
- d. Submit new or modified protocols for projects using sources of ionizing radiation to the RSC for review. Upon approval, follow established protocols for the use of sources of ionizing radiation.
- e. Conduct required procedures applicable to receipt and shipping of sources of ionizing radiation.
- f. Conduct and maintain inventories of sources of ionizing radiation, surveys, leak tests and usage logs for lab areas and applicable activities.
- g. With assistance from the RSC, determine decontamination and corrective action requirements for radioactive materials spills/incidents.
- h. Notify the RSC of any spills/incidents involving sources of radioactive materials and assist, as appropriate, in decontamination and cleanup procedures.

3. Radiation Workers. Individual radiation workers shall:

- a. Complete radiation safety training prior to beginning work in which sources of ionizing radiation will be used.
- b. Wear proper protective equipment and follow safe work practices when working with radioactive material.
- c. Keep exposures to ionizing radiation to levels as low as reasonably achievable (ALARA) by adhering to safe work practices, using applicable safety equipment and wearing required personal protective equipment (PPE).
- d. Where applicable or assigned, wear personal monitoring equipment or detectors in radiation work areas and while using radiation sources. Monitoring devices will be protected from inadvertent exposure, contamination and damage. Return devices to the facility RSC or supervisor, as required.
- e. Conduct personal monitoring for radioactive contamination when working with unsealed radioactive material at the conclusion of the work and prior to exiting the work area. If radioactive contamination

is detected on an individual or their clothing, contact the RSC or the supervisor for instruction.

- f. Comply with requests from OSHEM for bioassay measurements that may be required on a programmatic or case-by-case basis.
- g. Notify coworkers, supervisors, RSC or OSHEM when they believe a situation or observation may contribute to a potential safety hazard (e.g., spills).

4. Office of Safety, Health and Environmental Management

(OSHEM). The Office of Safety, Health, and Environmental Management (OSHEM) shall appoint the SI Radiation Safety Officer (RSO), who shall be responsible for coordination of requirements outlined in this Chapter, including:

- a. Providing training for radioisotope users, supervisors and RSCs.
- b. Developing policies and procedures for the safe use of radioactive materials and x-ray devices.
- c. Preparing radioactive materials licensing documents to ensure compliance with NRC regulatory requirements and other authorities having jurisdiction.
- d. Assisting Radiation Safety Coordinators in developing facility and program-specific elements to meet radiation safety requirements.
- e. Reviewing and approving protocols for the possession and use of radioactive material.
- h. Providing supervision and assistance for the management of emergencies or spills

5. Ancillary Personnel. Personnel visiting or frequenting a restricted area shall receive instructions concerning the ionizing radiation hazards in the area, commensurate with their activities.

C. HAZARD IDENTIFICATION

1. Initial Assessment. SI employees who may be exposed to ionizing radiation include those who possess, use or work in close proximity to sources of ionizing radiation. Sources may include (but are not limited to):

- a. Byproduct or accelerator-produced radioactive material.
- b. Naturally occurring radioactive material (NORM).
- c. X-ray devices, such as:
 - (1) Scanners for mail packages and visitor belongings.
 - (2) X-ray fluorescence (XRF)

- (3) X-ray diffraction (XRD)
- (4) Portable and open beam x-ray machines

2. Hazard Analysis. Health and safety hazards posed by ionizing radiation shall be identified and evaluated through the Job Hazard Analysis (JHA) process, which is described in [Chapter 4, "Safety Risk Management Program"](#), of this *Manual*.

D. HAZARD CONTROL

1. Exposure Monitoring

a. External Radiation Monitoring.

- (1) Personnel monitoring devices (e.g., dosimetry badges) shall be required for adult personnel who receive, or are likely to receive, a radiation dose in any calendar year in excess of 10 percent (10%) of current annual limits.
 - (a) Annual dose limits for adults shall be the least of either:
 - i. 5 rems: Whole body total effective dose equivalent
 - ii. 50 rems: Any individual organ or tissue will be the sum of the deep-dose equivalent and the committed dose equivalent
 - iii. 15 rems: Lens of the eye
 - iv. 50 rems: Skin of the whole body or any extremity
- (2) Annual occupational dose limits for minors are 10 percent of the annual dose limits for adults.
- (3) The dose equivalent to the unborn child during the entire pregnancy due to the occupational exposure of a declared pregnant woman is 0.5 rems.
- (4) The total effective dose equivalent to individual members of the public shall not exceed 0.1 rem per year and the dose in any unrestricted area from external sources shall not exceed 0.002 rem per hour.
- (5) Personnel monitoring shall also be required for the following:
 - (a) Minors likely to receive, in 1 year from external radiation sources, a deep dose equivalent in excess of 0.1 rem, a lens dose equivalent in excess of 0.15 rem or a shallow dose equivalent to the skin or extremities in excess of 0.5 rem
 - (b) Declared pregnant women likely to receive during the entire pregnancy from external sources a deep dose equivalent in excess of 0.1 rem.

- (6) Whole body exposures shall be evaluated with dosimetry badges on a quarterly basis, unless specifically exempt. If needed, direct-reading ionization chamber dosimeters shall replace or supplement a dosimetry badge for short durations (e.g., visitor usage).
- (7) Required dosimeters (except direct and indirect reading pocket ionization chambers and cesium iodide scintillators) that must be processed and evaluated to determine radiation dose, must meet accreditation by the National Voluntary Laboratory Accreditation Program (NVLAP).
- (8) Doses to the extremities shall be evaluated with dosimeter ring badges when necessary. Ring badges shall also be exchanged quarterly.
- (9) Procedures for receiving, wearing and returning personnel monitoring devices are listed in [attachment 2](#).

b. Internal Radiation Monitoring

- (1) Bioassay requirements will be established by OSHEM and may vary depending upon various factors such as type of material, quantity and the process used.
- (2) Internal radiation source exposure that shall require monitoring include:
 - (a) Adults likely to receive in 1 year an intake of 10 percent of the applicable annual limit of intake listed in [Table 1 of Appendix B to 10 CFR 20](#).
 - (b) Minors likely to receive, in 1 year, a committed effective dose equivalent in excess of 0.1 rem.
 - (c) Declared pregnant women likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem.
- (3) Special bioassay measurements may be required by OSHEM to verify the effectiveness of existing controls such as engineering and personal protective equipment.

2. Area surveys and monitoring

- a. Inventories of radioactive materials requiring surveys shall be maintained which identify quantity, type, form and date of manufacture for unsealed and sealed radioactive material used in laboratories. Inventories will include unused materials, stock solutions and labeled compounds and waste.
- b. Surveys shall be conducted to evaluate the magnitude and extent of radiation levels, concentrations or quantities of radioactive materials and the potential radiological hazard.

- c. Surveys shall be performed on a regular basis while work with radioactive materials is ongoing and shall be commensurate with the type and complexity of activities, quantities and frequency of use.
- d. Hands and forearms, shoes, and clothing shall be surveyed for radioactive contamination at the conclusion of work and prior to exiting the work area where unsealed radioisotopes are used, or where contamination is possible, except for tritium (H-3). If radioactive contamination is detected on an individual, contact the supervisor and RSC and begin the decontamination procedures outlined in Section 8.d.(3).
- e. Survey instruments and equipment used for radiation measurements must be appropriate to the type of radiation measured and shall be calibrated on an annual basis.

3. Use and control

- a. Licensed byproduct materials stored in unrestricted areas shall be secured from unauthorized removal or access. Licensed byproduct material used in unrestricted areas shall not be left unattended and be under constant surveillance.
- b. To the extent practical, process or other engineering controls (e.g. containment, decontamination or ventilation) shall be used to control the concentration of radioactive material in air.
- c. Ventilation Control
 - (1) Procedures involving volatile liquids, aerosols, dust or gaseous products, or procedures that might produce airborne contamination shall be conducted in a laboratory hood, glove box, or other suitably designed system.
 - (2) When practical, traps and/or filters shall be incorporated in the experimental set-up to ensure environmental releases are as low as possible.
 - (3) Fume hoods shall be labeled if radioactive materials are used or stored in the hood.
 - (4) Hoods used for work with volatile forms of radioactive materials must be evaluated by the facility RSC or OSHM to ensure that they meet the minimum requirement for air velocity at the face of the hood. Airflow shall be maintained so that there is no escape of air into the work place from the fume hood under normal conditions, including opening doors and windows, suction of other hoods, and air-conditioning systems. The velocity of the airflow shall be at least 100 linear feet per minute (lfpm). Refer to [Chapter 30, "Laboratory Safety,"](#) and [Chapter 34, "Ventilation for Health Hazard Control"](#) for general ventilation

hood requirements.

- (5) Fume hoods shall be used any time personnel are handling unsealed, potentially volatile forms of radioactive materials, unless specifically exempted.
 - (6) When process and engineering controls are not practical to control the concentrations of radioactive material in the air, intakes shall be limited and maintained as low as reasonably achievable through other controls (e.g., access control and limitation of exposure duration).
- d. The following personal protective equipment (PPE) shall be used at all times when working with radioactive materials:
- (1) Protective clothing, gloves, and shoe covers
 - (2) Protective barriers, shields and protective eye wear, whenever possible;
- e. Laboratory equipment and fixtures.
- (1) Equipment used in laboratories with unsealed radioactive material shall be labeled. The RSC shall be notified in advance when equipment is scheduled for surplus or disposal.
 - (2) Mechanical devices (e.g., tongs, remote handling tools, etc.) shall be used to assist in minimizing contact
 - (3) Once used with unsealed radioactive substances, equipment shall not be used for other work outside of the restricted area, to include repair, surplus or disposal, until fixed and removable contamination is within acceptable limits.
 - (4) Equipment and fixtures requiring repair by maintenance personnel or by commercial service contractors shall be demonstrated to be free of loose surface removable contamination prior to servicing.
 - (5) If emergency repairs are necessary on contaminated equipment and fixtures, the facility RSC shall be notified to ensure that necessary safeguards are taken.
 - (6) House vacuum lines are vulnerable to contamination. Whenever practical, it is advisable to use a separate vacuum system or inline trap whenever possible.
- f. Sealed sources.
- (1) All sealed radioactive sources above exempt quantities shall be identified and inventoried.
 - (2) The facility RSC, in conjunction with individual users, shall establish accountability procedures for control of sealed sources that may be used at alternate locations.

(3) Radioactive materials in gas chromatography equipment.

- i. Gas chromatography units in which radioactive materials are used shall be regulated as a sealed source.
- ii. Each cell containing a radioactive foil must have a label showing the radiation caution symbol with the words "CAUTION--RADIOACTIVE MATERIAL," and the identity and activity of the radioactive material. The radioactive foil shall not be removed from its identifying cell, except for cleaning, and shall not be transferred to other cells.

(4) Leak testing.

- i. Each sealed source containing radioactive material, except tritium (H-3), with a half-life greater than 30 days and in any form other than gas shall be tested for leakage and/or contamination at intervals not to exceed six months. In the absence of a certificate indicating that a test has been made within six months prior to a transfer, the sealed source shall not be put into use until tested. If there is reason to suspect that a sealed source may have been damaged or may be leaking, it must be tested for leakage before further use.
- ii. Records of source leak tests shall be kept in units of activity and maintained by the facility RSC.
- iii. If the source leak test reveals the presence of 0.005 microcuries or more of removable contamination, then the facility RSC shall immediately withdraw the sealed source from use and arrange for its decontamination and repair, or its disposal.
- iv. Any licensed sealed source is exempt from leak tests when the source contains:
 - 100 microcuries or less beta and/or gamma emitting material; or
 - 10 microcuries or less of alpha emitting material.

g. Control of Exposure from External Sources

(1) Entrance or access points to a high radiation area shall have one or more of the following:

- (a) A control device (e.g., an interlock of a door to an x-ray room) that, upon entry into the area, causes the level of radiation to be reduced below that level at which an individual might receive a deep-dose equivalent of 0.1 rem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.
- (b) A control device that energizes a conspicuous visible or

audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry; or

- (c) Entry ways that are locked, except during periods when access to the areas is required, with positive control over each individual entry.
 - i. Established exposure controls shall not prevent individuals from leaving a high radiation area.
 - ii. In addition to the above, additional control measures shall ensure that an individual is not able to gain unauthorized or inadvertent access to areas in which radiation levels could be encountered at 500 rads or more in 1 hour at 1 meter from a radiation source or any surface through which the radiation penetrates.

3. Placards, Signs and labels

- a. A "CAUTION -- RADIOACTIVE MATERIALS" sign shall be conspicuously posted on the doors to laboratory areas where radioactive materials are being used or stored in amounts greater than exempt quantities. The name and home telephone number of the individual responsible for the posted area shall be listed on the sign in order to facilitate contact in case of emergency. Upon termination of work with radioactive materials, the signs must not be removed from any room except by the facility RSC following a termination radiation survey.
- b. Radiation areas within a laboratory, (i.e., areas where radiation levels might expose individuals to 5 millirem (mrem) in any 1 hour; or a dose in excess of 100 mrem in any five consecutive days) shall be posted with the sign "CAUTION--RADIATION AREA."
- c. Storage areas for licensed materials greater than exempt quantities, as listed in [10 CFR 20, Appendix C](#), shall be conspicuously marked with a "CAUTION --RADIOACTIVE MATERIALS" sign. In addition, containers in which materials are transported or stored shall bear a durable, clearly visible label bearing the radiation caution symbol and the words "CAUTION--RADIOACTIVE MATERIALS." This label shall also state an estimate of the quantity of radioactive material, kinds of materials and the date of measurement or estimate of the quantity.
- d. All laboratory equipment contaminated with radioactive material must be marked with signs or decals or by other conspicuous means. Labeling is not required for laboratory containers such as beakers, flasks, and test tubes or liquid scintillation vials used transiently in laboratory procedures.
- e. Prior to removal or disposal of empty or uncontaminated containers

to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials.

4. X-Ray equipment safety

- a. X-ray equipment includes analytical, industrial equipment and scanners for packages and visitor belongings.
- b. Supervisors responsible for x-ray equipment shall:
 - (1) Ensure equipment-specific safety and operating procedures are written, and updated if there are changes in the equipment or the area. The written safety and operating procedures shall be available to all users.
 - (2) Ensure operating procedures are implemented
 - (3) Ensure all users have attended training outlined in Section E. of this Chapter.
- c. Areas where analytical or industrial equipment is located shall be conspicuously posted with "CAUTION – X- RADIATION" signs/labels.
- d. Equipment controls on radiation-producing equipment shall bear a label or decal with the statement: "CAUTION – RADIATION – THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED."
- e. A logbook and copy of operating procedures, for analytical or industrial equipment, shall be available for each unit. Each logbook (record) shall contain the following information:
 - (1) User log (e.g., user, date, voltage, amperes, time)
 - (2) Survey records (e.g., date, survey or instrument used, drawing or photograph of instrument/area, location surveyed, survey measurements in appropriate units).
 - (3) Safety device records (e.g., date, surveyor, description of the safety devices and results of the check, whether the device operative or inoperative).
- f. Radiation surveys shall be conducted annually and after maintenance work or repairs. Interlocks, visual and audible warning devices, and shutter mechanism checks shall be conducted along with each radiation survey.
- g. The facility RSC or OSHM shall determine the need for additional safety devices or procedures to ensure conformance with ALARA using the following criteria. The criteria for additional safety devices or procedures may include but is not limited to the following:
 - (1) The number of persons involved in the use of the radiation producing equipment.

- (2) The need to reduce the potential for unnecessary exposures.
- (3) The amount of personnel traffic near the radiation-producing equipment.
- (4) The age of the radiation-producing equipment.
- (5) The current safety devices in use.
- (6) The number of pieces of radiation-producing equipment located in one area.
- (7) Previous compliance during internal or external inspections.
- (8) Previous exposure reports.
- (9) Use of a portable x-ray unit at remote or off site locations.
- h. OSHEM shall review the structural shielding requirements of any new installation and proposed modifications to existing equipment to ensure conformance with applicable guidelines.
- i. X-ray equipment shall not be operated in a manner other than that specified in the operating procedures, unless the specific application has been reviewed and exempted by OSHEM and the RSC.
- j. Bypass of safety devices is not permitted unless specifically authorized by the RSC and OSHEM.
- k. The RSC and OSHEM shall be notified in advance of the procurement, transfer, or donation (received or given) of all x-ray equipment. The RSC shall be notified of any instrument taken out of service or returned to use.

5. Procedures for Procurement, Transfer, Receipt and Inventory of Radioisotopes

- a. The RSC and OSHEM shall be notified in advance of the planned procurement, transfer, or donation (received or given) of all radioactive material. Transfers of radioactive material shall be coordinated with the RSC and OSHEM. Transfers of items containing radioactive materials shall include appropriate disclosure to the recipient(s) regarding potential hazards and requirements for its possession, maintenance and use.
- b. The RSC shall be notified prior to purchasing radioactive materials to ensure the isotope and quantity are authorized and within the limits of possession identified on the SI materials license.
- c. Receipt of radioactive material packages.
 - (1) Receipt of radioactive material packages shall follow written facility-specific procedures.
 - (2) Materials shall be scheduled for delivery during regular business

days and during regular working hours.

- (3) Upon arrival, receiving personnel shall secure the package against unauthorized access and immediately contact the purchasing laboratory for pickup.
- (4) Laboratory representatives shall monitor and wipe test packages within 3 hours of receipt. Packages received after hours shall be secured, with monitoring conducted within 3 hours of the start of the next business day.
- (5) Laboratory staff shall ensure that all radioactive materials are included on a detailed inventory, identifying the radioisotope, type/form, quantity, date of receipt/issue and location.

6. Waste Storage and Disposal of Radioactive Materials

- a. An inventory of all radioactive waste shall be maintained on site. The inventory shall accurately describe the type, quantity and activity of the waste(s).
- b. Disposal of radioactive waste by a waste processing facility will be coordinated by the RSC and OSHEM.
- c. All radioactive waste must be segregated by type: dry solid, bulk liquid and liquid scintillation vials. Different types of waste shall not be mixed without prior approval and guidance from OSHEM. Radioactive waste shall not be mixed with any hazardous waste regulated by the Resource Conservation and Recovery Act (RCRA) unless specific authorization and guidance is provided by OSHEM.
 - (1) Dry solid waste: Dry solid waste is any dry, solid material, such as absorbent paper, gloves, pipettes, glassware, etc.
 - (a) Dry solid waste shall not contain any animal or bio-hazardous waste. Biohazard bags shall not be used to dispose of dry solid radioactive material.
 - (b) Dry solid waste that contains Phosphorus-32, Sulphur-35, or Iodine-125 shall be stored for decay. Waste containing other radionuclides shall be shipped for disposal by a radioactive waste contractor to a commercial disposal site. All waste containers must be labeled with a "Caution - Radioactive Material" label, the date and the radionuclide. Sharp objects, such as pipettes, syringes or broken glass must be packaged in cardboard or plastic boxes.
 - (2) Bulk Liquid Waste: Bulk liquid waste is considered to be one of two types: aqueous or organic. Do not combine radioactive waste with solvents or chemicals identified as an EPA hazardous waste, as defined by the [EPA \(40 CFR 262\)](#), unless specific authorization and guidance is provided by OSHEM. Disposal of this type of waste, termed "mixed" waste, is difficult

and expensive.

- (a) An aqueous liquid is a liquid that is readily dispersible or soluble in water. It must have a pH between 6 and 10. Aqueous liquid waste shall be stored in suitable nonmetallic carboys. The container shall be labeled with a "Caution - Radioactive Material" label and include the name of the Principal Investigator, chemical constituent, radionuclide, activity, and the accumulation start and stop date.
- (b) Organic liquids shall be stored in nonmetallic carboys or containers. The container shall be labeled with a "Caution - Radioactive Material" label and include the name of the Principal Investigator, chemical constituent, radionuclide, activity, and the accumulation start and stop date.
- (c) Bulk liquid waste shall be stored in secondary containment.

(3) Radioactive materials that are soluble or dispersible in water shall not be disposed via the sanitary sewer system unless in compliance with NRC, state and local regulations. Records of all authorized sanitary sewer disposals shall be maintained by the supervisor and facility RSC.

(4) Liquid Scintillation Vials.

- (a) Liquid scintillation vials shall remain tightly capped and accumulated for disposal. Records must be kept identifying the generator or waste process, radionuclide, activity and the accumulation end date.
- (b) Liquid scintillation vials which contain tritium (H-3) and/or Carbon-14 (C-14) with activities of less than 0.05 microcuries per milliliter shall be segregated from vials containing other radionuclides of higher activities.
- (c) Each facility will develop site-specific procedures for ensuring that radioactive waste is not combined with regular trash/non-hazardous waste.

c. Procedures for the Decay-In-Storage of Radioactive Wastes

- (1) The reduction and segregation of waste by isotope and waste stream is mandatory. Employees shall exercise diligence to ensure long lived isotopes are not mixed with isotopes with shorter half-lives. DO NOT MIX WASTE ISOTOPES.
- (2) Licensed radioactive material with a half-life less than 120 days may be held for decay-in-storage before disposal as regular trash/non-hazardous waste subject to the following procedures:
 - (a) Radioactive wastes shall be segregated by isotope in the

laboratory. Waste receptacles shall be clearly labeled and segregated by isotope. Tritium and Carbon-14 usage shall not be permitted in the same waste container as radioactive waste which will be held for DIS.

- (b) All materials known to be highly contaminated, such as pipette tips, columns and original containers of isotope shall be collected and bagged separately.
 - (c) All bags used to compartmentalize and segregate waste before storage for decay shall be labeled at the time they are sealed, with the isotope, date, and general quantity of activity.
- (3) All waste material shall be held for decay-in-storage (DIS) in areas designated by the facility RSC. The facility RSC shall approve waste collection containers, liners, and storage drums.
 - (4) Wastes shall be packaged in cardboard boxes lined with 4-mil polyethylene liners, 55-gallon steel drums, or fire retardant drums for DIS. Storage containers shall be labeled with the date the drum is filled and the isotope. Containers shall be arranged to allow for periodic inspection. In accordance with ALARA guidelines, containers shall be placed and shielded so the radiation levels within the DIS are minimized. Radiation levels in unrestricted areas shall be maintained at or below ALARA guidelines.
 - (5) The DIS area shall be inspected at least quarterly by the Radiation Safety staff. This inspection will include the following elements:
 - (a) Radiation levels of the DIS and surrounding areas shall be measured using appropriate instrumentation.
 - (b) Individual containers shall be inspected to assure no container has suffered a loss of integrity, and labeling requirements have been maintained.
 - (c) Any container found to have suffered loss of integrity shall be removed to the processing area, repackaged using a new container, and then placed back into DIS.
 - (6) Waste shall be monitored until radioactivity cannot be distinguished from background radiation levels before disposal. The waste shall be monitored at the surface, with an appropriate survey meter on the most sensitive scale with no interposed shielding.
 - (7) All radiation labels and markings shall be removed or obliterated prior to disposal.
 - (8) Records of disposal shall be maintained on site for 3 years and

shall include the following:

- (a) Date of disposal
 - (b) Survey instrument used, background radiation level, and radiation level measured at the surface of each waste container
 - (c) Name of the individual conducting the disposal survey.
- (9) The storage facility shall be maintained as a designated restricted area. Unauthorized access shall not be permitted and the facility shall remain secured when not under the supervision of authorized personnel.

7. Emergency Response Procedures

- a. Spills and environmental releases shall be reported to the RSC and OSHM.
- b. The local fire department and emergency response service shall be provided with the location of the radioactive waste storage area, isotope types being stored, activity, waste form, and average volume of waste.
- c. Accidental personnel exposure.
 - (1) Immediately report suspected inhalation, ingestion, injury or exposure involving radioactive materials or x-ray exposure to responsible supervisors, the RSC and OSHM. The supervisor and the RSO shall conduct an initial evaluation of the individual's exposure. In the event of a life-threatening incident that requires the use of emergency response personnel, treat the individual without regard to contamination. Where a suspected incident is not life threatening, personnel shall comply with any request from the SI RSO for bioassays. Such assessments may include body burden measurements, and/or the submission of urine samples for determining uptake.
 - (2) Immediately report all spills to supervisors, the RSC and the SI RSO.
 - (3) Perform any necessary emergency decontamination procedures, and take the necessary precautions to prevent the spread of contamination to other areas and equipment.
 - (4) Conduct corrective action which is recommended as a conclusion of the initial and follow-up evaluation.
- d. Decontamination.
 - (1) Decontamination of areas contaminated with radioactive materials shall begin promptly and shall follow the guidelines provided by OSHM. The extent of contamination and potential

hazard shall be determined by the supervisor with assistance from the facility RSC.

(2) Procedures for Radioactive Material Spills.

- (a) Notify the facility RSC and restrict the contaminated area. Do not allow anyone or anything to leave the contaminated area prior to being monitored for radioactivity.
- (b) Decontaminate hands by washing thoroughly for 2-3 minutes, repeatedly soaping and rinsing. Any mild cleansing agent may be used, but soaps are preferred to synthetic detergents. Organic solvents shall not be used, because they may make skin more permeable to radioactive contaminants. Remove contaminated clothing.
- (c) Don protective clothing (gloves, shoe covers) before starting clean-up work.
- (d) Limit the spread of contamination through the use of absorbent paper, etc.
- (e) Begin decontamination and label all waste containers. Waste generated during cleanup shall be identified as "radioactive waste".
- (f) Use wipes and survey equipment where appropriate to confirm the extent of contamination and to document areas that have been decontaminated.

(3) Decontamination of Personnel Contaminated with Radioactivity.

- (a) The supervisor, facility RSC and OSHEM must be notified immediately when exposure is suspected.
- (b) All body areas involved shall also be washed thoroughly for 2-3 minutes, repeatedly soaping and rinsing. Consideration should be given to the chemistry of the contaminant and a suitable agent for cleaning. Any mild cleansing agent may be used, but soaps are preferred to synthetic detergents.
- (c) Prolonged use of any one decontamination procedure shall be avoided. Organic solvents shall not be used, because they may make the skin more permeable to radioactive contaminants.

E. TRAINING

- 1. Prior to working with radioactive materials or working in a radiation area, each employee shall attend the initial facility-specific radiation training orientation program. The supervisor shall contact the SI RSO to schedule this training.

2. Ancillary personnel such as administrative, custodial and maintenance employees whose duties may require their presence in radiation work or temporary storage areas will attend awareness training prior to the beginning of work.
3. Refresher training which is applicable to the responsibilities of the worker shall be conducted as needed.

F. REQUIRED INSPECTIONS AND SELF ASSESSMENTS

1. Radiation use/storage areas, devices, and containers shall be inspected semi-annually for proper display of required warning signs and labels.
2. Each laboratory or radiation work area must be inspected each time there is reason to suspect a contamination incident.
3. The DIS area shall be inspected at least quarterly.
4. The immediate areas (e.g., hoods, bench tops, etc.) in which radioactive materials in amounts greater than exempt quantities are being used shall be surveyed biweekly.
5. Laboratory hoods shall be certified annually.
6. Inventory records, logbooks and survey data shall be reviewed semiannually.
7. The facility RSC or supervisor shall perform leak tests semiannually and store radioactive foils when not in use. Records are to be maintained on leak tests and source storage.
8. Survey instruments shall be available and calibrated annually. Calibration data shall be kept on-site and available for inspection.

G. RECORDS AND REPORTS

1. Survey instruments shall be calibrated annually. Calibration data shall be kept on-site and available for inspection.
2. Records of source leak tests shall be kept in units of microcuries and maintained by the facility RSC for 3 years.
3. The facility RSC shall maintain personnel monitoring records until termination of the applicable license which requires the monitoring.
4. The facility RSC shall maintain waste disposal records until termination of the applicable license.
5. The facility RSC shall complete an Isotope Inventory Record which will include transfers and maintain records as long as the material is possessed and for 3 years following transfer.

6. A record of all DIS materials will be maintained by the facility RSC and SI RSO/OSHEM. Records of the DIS waste monitoring results shall be maintained on site for 3 years following disposal.
7. Training records will be maintained by the RSC for three years after the record is made.

H. REFERENCES

1. U.S. Nuclear Regulatory Agency (NRC) [10 CFR Part 20](#), "Standards for Protection Against Radiation".
2. NRC [10 CFR Part 19](#), "Notices, Instructions, and Reports to Workers: Inspection and Investigations."
3. OSHA [29 CFR 1910.1096](#), "Ionizing Radiation."
4. [NRC Regulatory Guide 7.3](#), "Procedures for Picking Up and Receiving Packages of Radioactive Material."
5. [NRC Regulatory Guide 8.10](#), "Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable (ALARA)."
6. [NRC Regulatory Guide 8.13](#), "Instruction Concerning Prenatal Radiation Exposure".
7. [NRC Regulatory Guide 8.20](#), "Applications of Bioassay for Iodine 125 and Iodine-131".
8. [NRC Regulatory Guide 8.29](#), "Instruction Concerning Risks from Occupational Radiation Exposure."
9. [NRC Regulatory Guide 8.32](#), "Criteria for Establishing a Tritium Bioassay Program".
10. "Health Physics Procedures for Handling Radioactive Material Shipments at MSC", March 26, 1990.
11. U.S. Army Corps of Engineers (USACE), "Safety and Health Requirements Manual," [Engineering Manual \(EM\) 385-1-1](#), 3 November 2003, Section 06.E., "Ionizing Radiation".
12. National Fire Protection Association (NFPA) Standard 801, "Standard for Fire Protection for Facilities Handling Radioactive Materials," 2003.

ALARA Levels

The maintenance of radiation exposures as low as reasonably achievable (ALARA) for employees, visiting scientists, volunteers, students and the general public is a goal of the Radiation Safety Program. Although the current regulatory exposure limits provide a very low risk of injury, it is prudent to avoid unnecessary exposure to radiation. The objective of this philosophy is to reduce occupational and public exposures to as far below the limits as is reasonably achievable. The following goals are intended to assist this process by providing a means to quantify the success of this SI policy.

ALARA POLICY GOALS			
Exposure Type	Regulatory Limit (rem/yr)	ALARA Goal (rem/yr)	ALARA Investigation Level (rem/yr)
Whole Body	5.0	0.5	0.375
Organ or Tissue	50.0	5.0	3.75
Lens of the Eye	15.0	1.5	1.125
Skin or extremity	50.0	5.0	3.75
Minors (Whole Body)	0.5	0.05	0.0375
Embryo/Fetus ¹	0.5	0.05	0.0375
Member of the Public ²	0.1	0.01	0.0075

¹ Levels represented apply to exposure during the nine month pregnancy period.

² The concentration values of the regulatory limits in air are equivalent to the radionuclide concentrations which, if inhaled or ingested continuously over the course of a year, would produce a total effective dose effective dose equivalent of 0.05 rem.

Dosimetry Procedures

MONITORING INTERNAL AND EXTERNAL DOSE

1. Personnel Monitoring
 - a. Personnel monitoring is required for adults and minors likely to receive within a year, an external dose in excess of 10% of the applicable annual limits. Monitoring is to be provided for adults likely to receive within a year, an external dose of 500 millirem or minors likely to receive 50 millirem. Monitoring is required for declared pregnant women likely to receive an external dose in excess of 50 millirem, during a 9-month period.
 - b. Whole body exposures may be monitored individually with badge type dosimeters or direct or indirect reading ionization chambers.
 - c. Doses to the extremities which are likely to exceed 10% of the applicable annual limits may be evaluated with ring or wrist badges.
 - d. Where monitoring is not required, dosimeter badges may be worn as a way to supervise exposures, ensure that doses are maintained as low as reasonably achievable, and ALARA goals are met.
2. External Monitoring using Dosimeters
 - a. Badge dosimeters are available through OSHEM. Supervisors and RSC's may request permanent, visitor, and area badges by phone, fax or mail. Assigned or permanent badge requests should include the name, date of birth and work location.
 - b. Payment for dosimeters is made by reimbursement to OSHEM through an SI fund transfer. The cost of dosimeter badges each year will be provided to facilities, in addition to the cost for late, lost or damaged dosimeters. The transfer may be made annually, and should be forwarded to OSHEM by the last week in August. Contact OSHEM with questions regarding cost.
 - c. The records of individuals issued short term temporary visitor badges will be maintained by the RSC or facility representative. A record will include badge number, name, date assigned and terminated, date of birth, and location.
 - d. An individual that terminates employment or changes work duties and no is subject to monitoring, the facility representative should contact OSHEM and identify the individual and the effective date of termination from the program.
 - e. Badges, grouped by work location, will be issued and exchanged on a monthly or quarterly basis. Old badges should not be collected and returned to OSHEM until the new replacement badges have been received.

Attachment 2

- f. Monitoring results will be provided to the facilities as copies of the original data provided by the issuing laboratory.
- g. Requests from outside organizations for monitoring data on prior employees (where dosimeters were provided through OSHEM), may be forwarded to OSHEM. OSHEM will provide a summary of personal exposure history to organizations which request this information to employers on prior SI employees and researchers, if a signed authorization from the individual is received.
- h. Facility divisions, using unlicensed materials or processes may independently procure dosimeters, provided the vendor is certified by the National Voluntary Laboratory Accreditation Program (NVLAP). In addition, divisions which procure dosimeters independently shall be responsible for compliance with applicable regulations and program requirements associated with personnel monitoring.
- i. Use and care of external dosimeter badges should include the following:
 - (1) Once a dosimeter badge has been assigned and used, it cannot be reassigned to another individual. This applies to visitor badges as well as permanently assigned badges.
 - (2) When assigned a dosimeter badge, it should be worn at all times when there is a potential for occupational exposure to ionizing radiation. Dosimeters are not to be worn while individuals receive diagnostic or therapeutic medical treatment or for activities unrelated to employment. Exposure reports are documents of work related exposure only.
 - (3) Whole body badges should be worn on the outside of clothing or lead aprons using the collar, lapel, pocket or belt. Normally, the dosimeter is worn near the body location which would be likely to receive the highest exposure.
 - (4) Wrist badges should be worn on the palm side of the wrist, and finger rings should be worn with the label facing the palm side of the finger. If gloves are used, ring badges should be worn under the glove to avoid contamination.
 - (5) When not in use, keep dosimeters away from all sources of radiation, and extreme environments. Do not leave them in cars or take them home. They should only receive natural background and work related radiation exposure.
 - (6) Control dosimeter badges are used to determine background radiation at each location and any dose received by the badges in transit. They must not be assigned to any individual or used as an area monitor. Control badges should be kept with other badges not in use.

- (7) Badges should be kept free of contamination. If a dosimeter badge becomes contaminated, do not allow the badge to contaminate other badges or clean areas. Contact OSHEM as soon as possible for a replacement.
- (8) Return used badges to OSHEM as soon as possible. Lost or misplaced badges will be replaced with temporary badges as soon as possible. Contact OSHEM as soon as possible for a replacement.
- (9) Late badges are those returned after 90 days past the return date. Damaged badges include those with permanent marks on the plastic badge housing. Names and area descriptions that need to be marked on badges, should be written on tape and attached to the badge. Damage may include cutting, scraping the badge, placing stickers that cannot be removed or writing on the badge with indelible ink.

2. Internal Monitoring - Bioassay

- a. Internal monitoring is required for adults likely to exceed, within one year, an intake in excess of 10 percent of the applicable Annual Limits of Intake (ALI's). Minors and declared pregnant women likely to receive, within one year, an intake which results in a committed effective dose equivalent in excess of 50 millirem. Bioassay methods may include urine or fecal analysis, or invivo monitoring, such as an external scan of a portion of the body with an appropriate detector.
- b. Special bioassay measurements may also be required as a part of the SI Radiation Safety Program or NRC license requirement. If such monitoring is to be implemented, OSHEM shall notify the division with implementation requirements.

Attachment 3

Tritium Exit Sign Management Plan

To ensure that the SI is fully compliant with all regulatory requirements pertaining to the purchase and possession of tritium exit signs (TES), a means of monitoring purchases, installation and disposition of the signs must be established. This management plan addresses requirements pertaining to TES used by the SI in all building locations. This Plan outlines procedures for:

- Centralized purchase and documented inventory
- Installation and periodic inspections
- Training for associated staff and facility management
- Emergency response and reporting of lost or damaged signs
- Proper disposal, reporting and recordkeeping

This Plan is based on the requirements of SI *Safety Manual* Chapter 32, Ionizing Radiation and the Nuclear Regulatory Commission (NRC) regulations on control and management, inventory, reporting, training and disposal. Specific codes are listed as References.

BACKGROUND

Tritium exit signs are self luminous signs containing radioactive hydrogen and a phosphor material, which glows without electric power or batteries. These exit signs serve a safety function by remaining illuminated during power outages and emergencies and complying with building codes for emergency egress. The signs are sealed and have an expected duration of use of approximately 10-12 years before they expire and need replacement.

Tritium exit signs have a label with the words “Caution Radioactive Materials” and the radiation symbol. The label may not be visible in the sign’s installed position. Photoluminescent signs are another type of self-powered sign that does not contain radioactive materials. If in doubt, contact OFMR.

Tritium exit signs (TES) belong to a group of items which are considered “generally licensed devices”. Manufacturers of TES are specific licensees and purchasers are known as general licensees. Purchasers do not need authorization from the NRC or a state regulatory agency to purchase and possess the signs. However they are subject to specific regulatory requirements regarding handling, transfer and disposal. They are also subject to NRC or agreement state inspection and enforcement action, including fines for violating those requirements. Manufacturers must inform the NRC of the names and addresses of the purchasers, including the model and serial number and date of purchase of the TES.

RESPONSIBILITIES

1. **Facility directors** will ensure that all department and division requests for TES are forwarded to the Office of Facilities Management and Reliability (OFMR) Fire Alarm Shop for registration prior to purchase.
2. **The Office of Facilities Management and Reliability (OFMR)**, Systems Engineering Division, has overall responsibility for the day-to-day compliance with requirements pertaining to TES. The OFMR Fire Alarm Shop will maintain an up-to-date inventory of

TES and their locations where they are installed or stored as well as lost, stolen, damaged or expired TES that have been removed and stored for disposal.

3. OFMR staff and facility management will conduct and document **periodic visual observations**, at least once per year, of all previously identified TES to verify the inventory and monitor the condition, and report any evidence of damage. OFMR will contact OSHEM to initiate corrective actions for the isolation, removal and cleanup of any TES determined to be damaged or in poor condition. When a TES has been found to be damaged, OFMR will isolate and ventilate the area and notify the Office of Safety, Health and Environmental Management (OSHEM). Removal of the sign, cleanup and a survey of the area will be done by authorized individuals designated to conduct these activities.
4. The Office of Safety, Health and Environmental Management (OSHEM) will submit a report to the NRC regarding TES which are transferred for disposal, stolen, lost or damaged, within 30 days of such actions.
5. **The Office of Engineering, Design and Construction (OEDC)** will ensure that plans to incorporate TES in new construction projects will be coordinated with OFMR and included in the SD 410 review process.
6. Renovation projects conducted through outside contractors or internally, by SI staff, will be coordinated with OFMR to ensure TES removed or installed are reflected in the SI inventory and disposed of properly.

GENERAL REQUIREMENTS

1. Tritium exit sign labels cannot be removed and signs cannot be abandoned.
2. Lost, broken or stolen signs must be reported to the NRC within 30 days.
3. Signs cannot be sold or transferred to another entity unless the device is to remain in use at its original intended location. In such cases, the NRC is to be notified within 30 days.
4. TES must not be disposed of as normal trash. Proper disposal will require the transfer to an entity specifically licensed to accept the sign. Within 30 days of transfer for disposal, a report must be submitted to the NRC that includes: the manufacturer's name, model number and serial number; the name, address and license number of the entity receiving the device; and the date of transfer.
5. Renovation and construction work, contracted and in-house, will include an inventory of TES which will be affected in the project area and store TES for reuse or disposal as part of the planned project.
6. All transfers for disposal or to recycle exit signs shall be conducted by a contractor licensed to transport radioactive materials.

HAZARD CONTROL

Intact radioactive exit signs do not pose a radiological hazard. The Tritium gas is sealed in specialized glass tubes and the gas cannot be released unless the internal tubes are broken or cracked. Tritium emits low energy beta particles and cannot penetrate the glass tubes.

Special precautions are not required to handle intact signs other than to avoid breakage. If an exit sign is broken, evacuate the affected area and if possible, ventilate the area and immediately notify OFMR and OSHEM.

Tritium exit signs must not be disposed of as normal trash. Disposal of TES will be conducted through OSHEM to ensure compliance with Department of Transportation (DOT) and Nuclear Regulation Commission (NRC) regulations and the device registration requirements.

EMPLOYEE AWARENESS TRAINING and SAFE WORK PRACTICES

1. **Employees working with TES**, occupants working in areas where TES are installed and Safety Coordinators and committee members are to be provided TES awareness training to include:
 - a. Location of TES installed in their areas.
 - b. Identification of TES, hazards associated with damaged signs and requirements for proper disposal.
 - c. The name and phone number of the facility point of contact to whom reports of disturbance, damage or changed conditions of TES are to be made.
2. Personnel **assigned to be first responders** to isolate the areas where TES have been damaged and may be leaking are to be further trained in the safe work practices for securing the sign and area.
3. Supervisors and the safety coordinators are to **suspend work activities** in areas where a damaged sign is suspected of leaking and personnel are without proper controls and personal protective equipment in place.

CONTACTS:

OFMR – Fire Alarm Shop 202-633-1560

OSHEM – Environmental Management Division 202-633-2530

REFERENCES:

[NRC 10 CFR 31.5](#)

[NRC Fact Sheet on Tritium Exit Signs](#)

DOT 49 CFR 171