



# **Xavier University of Louisiana**

## **Safety Radiation Manual**

## **1.0 Introduction**

This document has been developed by Environmental Safety and Health Department and Office of Sponsored Programs with review of the Radiation Committee in order to satisfy compliance with Louisiana Departmental of Environmental Quality (LADEQ), Occupational Safety Health Administration (OSHA), and United States Nuclear Regulatory Commission (NRC).

### **1.1 Authorization**

Xavier University of Louisiana is authorized to possess, store, and use radioactive materials as stipulated within the educational radioactive materials license issued by the Louisiana Radiation Protection Division of the LADEQ. Furthermore, Xavier University's educational license allows the use of radioactive materials for teaching and research through the operation of an internal radiation safety and control program. Copies of these licenses are available for inspection in Office of Environmental Safety & Health and/or from the Radiation Safety Officer.

### **1.2 Responsibilities and Authority**

All persons involved with the handling, use and storage of radioactive materials and radiation sources have the general responsibilities to:

1. Assure that Xavier University personnel, students and visitors are not subject to undue radiation exposure;

2. Assure that all federal and state regulations have full compliance;
3. Assure that special project restrictions have full compliance;
4. Assure that local and state codes and ordinances have full compliance;
5. Assure that the integrity and usefulness of Xavier University facilities are not compromised;
6. Assure that maximum standards of good practice and safe handling are maintained.

Each person who handles radioactive materials or radiation sources must recognize that the ultimate success of a radiation safety program is the responsibility of individuals in their daily work.

## **2.0 ALARA PROGRAM**

Xavier University's radiation safety program will be conducted in such a manner so that exposure to faculty, staff, students and the environment will be maintained As Low As Reasonably Achievable (ALARA).

Every faculty, staff and student of the university are protected from unnecessary exposure to ionizing radiation by federal and state law. Accordingly, every employee and student are empowered to minimize his or her radiation exposure by being advised of their recorded radiation exposure in relation to regulatory limits, and (b) informed of protective practices that can reduce exposure through education and training.

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The United States Nuclear Regulatory Commission defines "maximum permissible dose limits" for individuals who are exposed to radioactive material or radiation sources during the course of their employment. These limits, which have been recommended to the Nuclear Regulatory Commission by various government and private advisory organizations, are believed to represent exposure levels that should not result in harm to the worker or his/her offspring during their lifetime.

However, Xavier University operates its program so as keep all radiation exposures and releases of radioactive material to the environment to the lowest possible levels. This concept is incorporated in the regulations by requiring that all environmental releases and personnel doses be in accordance with ALARA, and thereby not simply meeting published regulatory limits. A program fully complying with ALARA will be at or below 10% of such limits.

Table 1 lists the maximum permissible doses to personnel from ionizing radiation, as described in 15A NCAC 11.

**Table 1. Permissible Occupational \* and ALARA Doses**

Body Part Exposed	Permissible Dose (Rem/Year)
Whole body (head, trunk, gonads, arms above elbows, legs above knees)	5.0
Lens of the eye	15.0
Single Organ	50.0
Hands and forearms, ankles and feet	50.0
Skin of whole body	50.0
Embryo/Fetus *	0.5 rem during gestational period

*\*"Occupational dose" refers to the radiation dose received by an individual in a restricted area or in the course of employment in which the individual's assigned duties involve exposure to radiation or licensed radioactive material, whether in the possession of the licensee or registrant or other person.*

### **3.0 Grant and Contract Proposals**

All proposals to outside agencies involving the use of radioactive materials or radiation sources must be routed through the Radiation Safety Committee. The Radiation Safety Committee may approve such applications. The originator of the proposal shall forward a copy of the proposal and approval form to the Radiation Safety Committee. The Radiation Safety Committee conducts reviews of proposals for their radiological safety content only.

### **4.0 Shipping, Receiving and Handling**

Xavier University will ensure the following procedures when handling radioactive products.

#### **4.1 Radionuclide Orders**

Radionuclides may only be ordered by approved users for a project. The purchase requisition, including the name of the approved user, is transmitted to the Radiation Safety Officer. The Radiation Safety Officer will review the requisition to assure that the purchase will not exceed the license limits and that the radionuclides are authorized for that particular project. The purchase requisition will be signed by the Radiation Safety Officer, who will process the requisition .

Purchase requisition approval is also required for any equipment containing radioactive sources, such as gas chromatographs equipped with electron capture detectors.

## **4.2 Delivery of Radioactive Materials**

The Radiation Safety Officer must be notified promptly upon arrival of the radioactive material so that proper inventory and receipt procedures can be completed. Federal and state regulations require that Xavier University will be able to verify the total quantities of radioactive materials on hand, and show an inspector the physical location of each individual shipment or prove that it has been properly removed or shipped for disposal.

## **4.3 Receiving and Monitoring of Isotope Shipments**

All radioactive isotope packages are required to be received and inspected by the radiation officer or designated personnel before release to the approved users. All shipments received by the Xavier University will be inspected for leakage, breakage or defective packaging upon receipt. A qualified staff member will wear latex or plastic gloves and safety glasses at all times during inspection and opening of any package known or suspected to contain radioactive materials.

If the radioactive material is of normal form, the innermost container which actually contains the isotope will be visually examined for breakage, visible leakage, or faulty packaging. If any irregularities in packaging are detected, the package will not be released.

Once it is determined that an isotope package is suitable for release, it will be logged and released. If the potential end user is not approved for a particular shipment for any reason, the shipment will be held until proper approval is obtained.

Additional information concerning each isotope kept on record includes date of receipt, reference date, physical and chemical form of the isotope, activity, volume or weight, specific concentration, manufacturer and person who inspected the package.

#### **4.4 Waste Handling Procedures**

Xavier University's radioactive materials license imposes severe restrictions on waste-disposal methods. Therefore waste disposal should be handled by the Radiation Safety Officer or designated personnel.

Waste materials can be generally classified in the following matter:

1. Miscellaneous solid waste (glassware, paper towels, dissecting instruments, gloves, etc.);
2. Major aqueous-solution waste (reaction solutions, primary dilutions of stock solutions, residual stock solutions, scintillation fluid, etc.);
3. Minor aqueous waste solutions (third rinses from glassware, radioactively decayed solutions containing less than microcurie amounts of activity, etc.);
4. Major organic-waste solutions;
5. Permanently contaminated equipment.

Waste shall be segregated by solid, aqueous liquid and organic liquid. It shall be stored only in approved and appropriately labeled containers.

***NOTE: Any container which could be mistaken for a container for ordinary trash will not be approved.***

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Radioisotopes with half-lives greater than 100 days may be combined provided no chemical hazard is created. Radioisotopes with shorter half-lives should be stored separately. Each container of waste shall have a label to indicate the isotope(s) total content in millicuries and for short-lived material the date the material was placed in the container should be included.

The Radiation Safety Officer and/or designee will schedule radioactive waste pickups at the generating laboratories on a routine basis. To ensure that waste is handled in a safe and efficient manner the following is required:

1. Dry and liquid waste shall not to be mixed. If it is determined that waste has been mixed it shall be the generator's responsibility to ensure separation.
2. Remove all radioactive labels from short half-life waste that is to be held for decay.
3. Liquid waste is to be stored in containers provided by or approved by the Radiation Safety Officer and/or designee. Waste in unapproved containers will not be picked up. The generator will be required to transfer the waste to an approved container.
4. Each box, bag or container of radiation waste shall have affixed a fully completed radioactive waste label.

Waste will be disposed of through shipment to a radioactive waste burial site. Solid and organic radioactive waste with half-lives greater than 100 days will be disposed of in this manner:

a. Dumped down the drain: Water soluble radioactive waste, i.e., aqueous liquids can be disposed of in the sanitary sewer. The concentration of the radioactive waste and total millicurie quantity disposed per year is governed by state regulations. ***NOTE: prior to disposing of radioactive waste in this manner the generator shall inform the Radiation Safety Officer to assure that the concentration and annual quantity are not being exceeded.***

b.. Designated as Hazardous Non-radioactive Waste: Organic scintillation medium containing 0.05  $\mu\text{Ci}$  of  $^3\text{H}$  or  $^{14}\text{C}$  or less per ml/gram of material may be disposed of as hazardous waste provided the applicable regulations for the chemicals are followed.

c. Incineration: Disposal by incineration is the favored method of disposal when incinerator facilities are available. ***NOTE: sealed sources and large pieces of glass and metal shall be segregated from other dry waste.***

Disposal of radioisotopes by any of these methods requires that traceable records of the amount and physical/chemical nature of the disposed material kept and maintained.

#### **4.5 Transfer and Shipment of Radioactive Materials**

Federal and state regulations restrict the transfer of radioactive materials, except in certain carefully specified situations, to persons holding valid radioactive materials licenses. A copy of the receiver's license must be provided to the Radiation Safety Officer before the shipment or transfer can be authorized.

The Radiation Safety Officer will assist in the transfer, including providing specific information on packaging and labeling packages for shipment, and advice on acceptable shipment methods and applicable regulations and restrictions. The records of transfers are maintained with the Radiation Safety Officer and/or Environmental Health & Safety Department.

#### **4.6 Storage of Radioactive Materials**

Individual users are expected to limit the amount radioactive materials which they are actively using. The intent of this policy is to ensure the security of radiological materials during emergencies such as fires, explosions or natural disasters.

All storage locations must be posted with approved radiation warning signs, which are available from the Radiation Safety Officer. Storage of radioactive materials in locations where food or beverages are also stored is not permissible.

#### **4.7 Radioactive Materials Accountability**

Xavier University is required by the terms of its radioactive materials license, and state and federal regulations, to be able to account for all radioactive materials under its control. Records are maintained in the laboratories of receipts, disbursements, transfers, and ultimate disposals of radioactive materials. Records in the labs must reflect known locations and known users.

Individual users must keep internal records of the radioactive materials they receive from the Radiation Safety Officer, how they are used, what the current content of each individual bottle or vial, and what material remains unused in storage. The Radiation Safety Officer and/or designee will perform a physical inventory audit to verify records annually.

Exchange of radioactive material between approved users requires prior approval by the Radiation Safety Officer and/or designee. Radioactive material may be used and stored only in rooms previously approved by the Radiation Safety Officer and/or designee.

#### **5.0 Registration of Machines Producing Ionizing Radiation**

Regulations of the Louisiana Nuclear Energy Division require that all equipment that produces ionizing radiation must be registered with the Division, which then issues a certificate of registration to the owner of the equipment. A copy of the certificate must be posted on or near the machine.

Machine sources included under the registration requirement include diagnostic X-ray machines of all classes (e.g., field-portable, fluoroscopic, special-procedures, panoramic-dental, crystallogical, etc.), therapeutic X-ray machines of all classes (e.g., deep-therapy, superficial-therapy, supervoltage, etc.), industrial X-ray units, analytical instruments (e.g., diffraction, fluorescence, etc.), and accelerators (e.g., synchrotron, cyclotron, electron-therapy systems, etc.).

Although the Radiation Safety Office has the responsibility of completing registration forms, it is incumbent upon individuals initiating purchase of radiation producing equipment to notify the Radiation Safety Office of the arrival of such equipment. Such purchases must have been approved previously by the Radiation Safety Officer.

When an instrument is moved to a new location, or is transferred from the campus, the Radiation Safety Officer and/or designee must be notified to assure that records are current. Physical inventories of radiation producing equipment will be made on an annual basis. Movement of a radiation producing machine from one location to another requires prior authorization from the Radiation Safety Officer, which will be granted only after preliminary safety and shielding analyses have been completed.

## **6.0 New Facilities Approval**

New buildings or renovated areas in old buildings in which radioactive materials or radiation sources are to be used must be approved by the Radiation Safety Committee. The Radiation Safety Officer and/or designee should be involved as early as possible in

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the planning of new facilities. Proper design considerations can result in significant savings to the university by reducing initial costs and avoiding expensive corrective alterations later.

## **7.0 Personnel Monitoring**

Every employee of the university who is handling radioactive materials or using radiation sources of types and quantity such that it is possible to receive an exposure greater than 10% of the applicable radiation dose standard specified by the state of Louisiana shall be included in the radiation monitoring program. Long-term visitors, post-doctoral fellows and other such persons working with radiation as described above shall also be covered by the program. Other persons may be assigned to the personnel monitoring program at the discretion of the Principal Investigator and/or the Radiation Safety Officer.

Students who are enrolled in courses involving the handling of radioactive material or use of radiation sources may be assigned to the radiation monitoring program. The decision to assign or not to assign will be a joint decision between the instructor and the Radiation Safety Officer. If a decision cannot be reached, the Radiation Safety Committee will make the determination.

When persons are assigned to the monitoring program they will be asked whether they have ever received an overexposure of radiation. If the answer is affirmative, the person will not be allowed to work with radiation until the past radiation exposure records have been obtained and evaluated.

Good practice dictates and state and federal laws require that Xavier University provide information to users that their radiation doses are within regulatory limits and also that individuals be notified if their radiation doses exceed radiation protection guidelines.

The monitoring program includes, where applicable, personal body dosimeters, personal extremity dosimeters, rate sensitive area monitors, portable survey instruments, portable and fixed air sampling instruments, surface smears and bioassay procedures. Personal dosimetry devices are available for detection of beta, X and gamma and neutron radiations; supporting techniques allow assessment of alpha inhalation hazards. At the time of approval, the Radiation Safety Officer will determine the type of monitoring techniques to be used for that project.

Excessive exposure detected on a personal dosimeter requires immediate notification of the wearer, initiation of any appropriate medical assistance and a determination of the cause of the exposure. When necessary, The Radiation Protection Division and The United States Nuclear Regulatory Commission offices will be notified of the incident. These agencies can be of assistance in assuring the best available medical care, and also in procuring support personnel for facilities recovery. Anyone who suspects an overexposure should report this immediately to the Radiation Safety Officer, who can be reached at the telephone numbers listed at the front of this manual.

Records of individual radiation dose histories are maintained by the Radiation Safety Officer. The Environmental Health and Safety Office will respond to requests for radiation exposure histories from employers after an individual leaves the campus.

### **8.1 Personnel Monitoring Program**

All persons handling radioactive materials, or using radiation sources of types and quantity, such that it is possible to receive greater than 10% of the applicable radiation dose standard specified by the state of Louisiana, is required to wear a dosimeter. If a person has been exposed to radiation over the allowable limit prior to his coming to the university, then contact will be made with their previous employer to obtain a copy of that person's cumulative exposure history, and will be used in closely monitoring that person's cumulative exposure while working here at the university.

There are many different types of dosimeters that may be used for monitoring. They include the following:

- a) K1, whole body dosimeter worn outside clothing for measuring deep and shallow doses for beta, gamma and x-rays.
  
- b) U3, ring dosimeter which can be specified for the right or left hand. Used for measuring deep and shallow doses for beta, gamma and x-rays.
  
- c) K8, whole body dosimeter worn underneath the apron of those working with x-ray equipment. Used for measuring deep and shallow doses for beta, gamma and x-rays. (This dosimeter can also be assigned as a secondary dosimeter for persons

who will be working in another location other than the primary location they are assigned. This enables us to receive separate dosimeter readings for each location.)

d) Z1, whole body dosimeter which includes dose readings to neutrons, in addition to the standard deep and shallow dose levels for beta, gamma and x-rays.

e) I1, whole body dosimeter which provides exclusive measurements for neutron dosages.

f) X8, used as environmental control dosimeters for measuring deep and shallow doses for beta, gamma and x-rays.

Dosimeters are issued either on a temporary basis (good for one calendar quarter only), or on a quarterly basis (a renewal dosimeter is received at the beginning of each calendar quarter) or on a monthly basis. All new participants are issued a temporary dosimeter for the first quarter of their enrollment in the program. If any participant continues to work with radioactive materials longer than one quarter, they are placed on our permanent program to receive their dosimeter(s) routinely on a quarterly or monthly basis as indicated on their request form.

Each participant must return his or her dosimeter(s) within a specified number of days after their wear period to receive an accurate reading with properly assigned control dosimeters.

The Radiation Safety Officer will examine the recorded results upon receipt in order to determine whether or not any control dose levels have occurred. Whole body dose that is found to be greater than or equal to 100 mrem, or if a ring dosimeter dose level is found to be greater than or equal to 1000 mrem within the time of one calendar quarter, it will be investigated. The results of the investigation along with any corrective actions will be documented.

Any person needing to be dropped from the dosimeter program must notify the Radiation Safety Officer, and provide a letter requesting his or her removal from the program.

## **8.2 Site Monitoring**

Site-monitoring checks include smears to establish removable contamination levels and where applicable portable-survey-meter measurements of radiation levels and surface contamination levels. Checks also include visual inspection of working conditions, observations of operating techniques, storage of waste, labeling of containers, posting of warning signs, radioisotope disbursement records, instrument calibration and discussions with site personnel to suggest improvements in radiation safety practices. This will be conducted three times a year by the Radiation Safety Officer and/or designee.

## **8.3 Testing of Sealed Sources for Leaks**

### Procedures:

- 1) All sealed beta sources greater than 100  $\mu\text{Ci}$  and all sealed alpha sources greater than 10  $\mu\text{Ci}$  are tested for leaks upon arrival.

- 2) Sealed beta sources larger than 100  $\mu\text{Ci}$ , which are not stored under the direct control of the Radiation Safety Officer are tested for leaks at six-month intervals.
- 3) Sealed alpha sources larger than 10  $\mu\text{Ci}$ , which are not stored under the direct control of the Radiation Safety Officer are tested for leaks at three-month intervals.
- 4) At the time any sealed source is removed from storage, it is tested for leaks.
- 5) Certain sources will be tested for leaks either more or less frequently at the stipulation of the Louisiana Radiation Protection Division (LARPD).
- 6) Analysis of test for leaks will be by procedures and instrumentation documented to have a limit of detection of less than 0.005  $\mu\text{Ci}$ .
- 7) Records of sealed-source test for leaks are maintained by the Radiation Safety Officer.

## **9.0 Declared Pregnant Women**

Once a woman has declared herself to be pregnant, the allowable exposure for the remainder of the gestation period is limited an effective dose up to 0.5 rem. The regulatory definition of a declared pregnant woman is:

*"A women who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception."*

Anyone that has declared herself pregnant shall report this information the Radiation Safety Officer and the Office of Environmental Health & Safety.

## **10.0 General Rules for Radioactive Materials**

1. Eating, drinking, smoking or the applications of cosmetics are not permitted in areas where radioactive materials are used or stored.
2. Personnel monitoring devices (TLD badge, finger badge, wrist badge) prescribed for the area must be worn.
3. Protective clothing (gloves, laboratory smock, coveralls, respirator, shoe covers, etc.) prescribed for the area must be worn.
4. Proper containment (absorbent paper, trays, secondary liquid containers) required for the operations must be in place.
5. Fume hoods are to be used for all operations that potentially involve release of air-borne materials, including gases, volatile compounds and dusts and aerosols (minimum air flow shall be 85 fpm).
6. Prescribed radiation detection equipment and calibrated survey instruments must be available and known to be working.
7. Work areas should be monitored when an operation is completed, or at the end of the work period.

8. Radioactive materials must be stored and shielded in the manner prescribed for the area and secured to restrict unauthorized persons from using or removing the material.
9. All bottles, jars, boxes and cabinets containing radioactive materials must be clearly labeled as to the radionuclide, quantity and date, and initialed by the responsible person.
10. All entrances must be properly labeled with signs appropriate to the hazard and posted with the names and telephone numbers of individuals to be contacted in emergencies.
11. Initial runs on new procedures should be made with nonradioactive materials or less than 10 microcurie amounts of radioisotopes.
12. Procedures should be designed to reduce to a minimum transfers from container to container, bench to bench and room to room, as a means of reducing spills.
13. Radiation levels in work areas should be estimated before an operation is begun so that proper shielding and remote-handling equipment can be employed to reduce individual exposures.
14. Individuals unfamiliar with radiation hazards and emergency procedures must not be permitted to work with radioactive materials.
15. In accord with safe and acceptable laboratory practices pipetting by mouth in areas where radiation materials are being used is forbidden.

16. All equipment, glassware and other contents of an area in which radioactive materials are being used, or have been used, should be considered as contaminated until properly monitored.

17. Any injury, no matter how slight, involving radioactive materials must be monitored to determine if the wound is contaminated.

### **11.0 Signs, Notices and Labels**

Regulations of the Radiation Protection Division require that signs be posted to inform the public of the existence of a hazard in areas where radioactive materials and radiation sources are used and stored. Posted signs must comply with federal regulations which are in agreement with international symbols for recognition of hazards. These signs are printed with magenta ink on a yellow background, and bear the word "caution" at the top, the standardized three-bladed "propeller" symbol for radiation in the center and a descriptive prescribed phrase denoting the magnitude of the hazard at the bottom.

In addition to signs indicating the presence of a radiation hazard, each area must be marked with a notice identifying individuals to be called in an emergency and their current telephone numbers at the university and at home. Individuals to be listed on the notice include:

1. Principal user
2. Alternate person knowledgeable of the specific area (if possible)

3. Radiation Safety Officer

4. Environmental Health Office

## **12.0 DECONTAMINATION**

Although Radiation Safety Officer will assist in decontamination operations, it is standard policy of the nuclear industry that the person who is responsible for contamination has the obligation to assume primary responsibility for decontamination. Immediate reaction to a contamination situation frequently can prevent serious side-spread problems. In any situation involving contamination, the first concerns are to determine its extent and to minimize the spread of radioactive materials. This is accomplished in four steps:

1. Monitor to determine the extent of contamination.
2. Isolate the contaminated area.
3. Institute anti-contamination procedures to minimize the spread of contamination.
4. Establish a "hot zone" to control contamination spread during team operations.

## **12.1 Monitoring**

Monitoring determines the extent of contamination, the effectiveness of contamination control, and the need for further decontamination efforts. The monitoring of personnel for contamination of clothing and skin surfaces is pertinent to contamination control. Ground surveys of the affected area should be conducted to define the degree of contamination. Two methods of plotting the data, a radial plot or a grid plot, are often used. Typical documentation information includes:

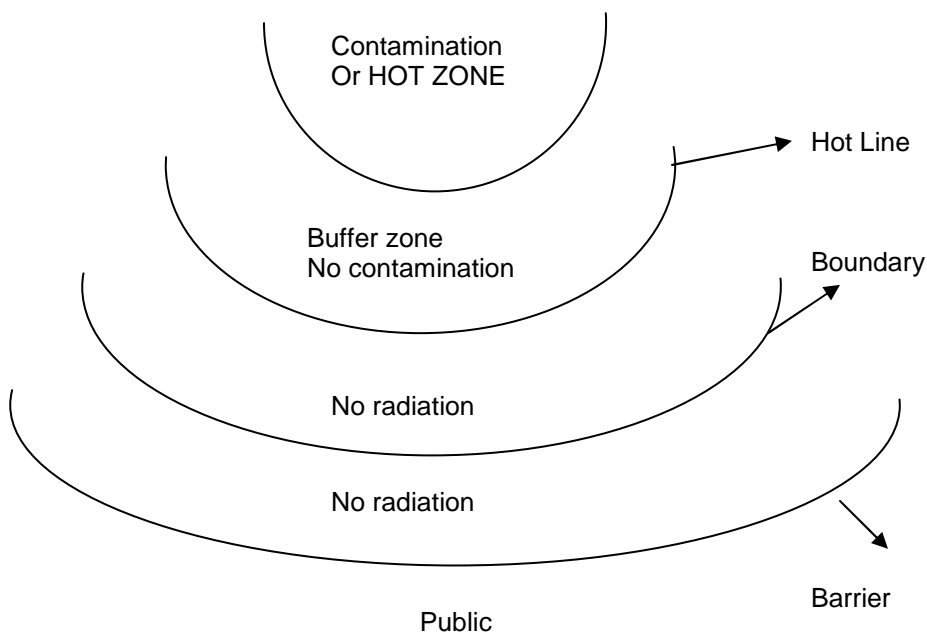
1. Survey date and time.
2. Location of incident
3. Identification of instruments used, including serial number.
4. Specific location of measurements (a sketch or drawing may be useful).
5. Contamination levels measured. Equipment surveys will be taken in counts per minute (cpm); however, the instrument efficiency must be known so that the reading can be converted to disintegrations per minute (dpm).
6. Identification of individuals taking the survey.

## **12.2 Isolation of the Contaminated Area**

The boundaries of the contaminated area should be marked to prevent inadvertent entry. Ideally, the barrier line should be placed outside of the boundaries of the

contaminated area so that radiation levels are at or near normal background at the barrier line. The buffer area delineated should be between the boundary and barrier. It is better to delineate an area that is too large than one that is too small.

**Figure 1**



### 12.3 Anti-contamination Procedures

While it may be difficult to protect equipment from contamination because of size and use, this problem can be reduced through proper selection and control. The equipment selected must be clean to reduce contamination pickup and to reduce decontamination problems. Certain equipment, such as beta-gamma meters and probes, can be enclosed in plastic bags to reduce the spread of contamination. However, alpha-survey instrument probes must be left uncovered. The "hot zone" is an arbitrarily

established control line separating the contaminated area from the contamination-free area and the stepoff pad (SOP) is generally situated upwind from the contaminated area. All personnel and equipment entering and leaving the contaminated area are channeled through the hot zone at the stepoff pad (SOP). The requirements for entering should also be posted. Additionally, step off pads and containers for disposal of protective clothing and trash should be set up. No individual, materials or equipment should be allowed to leave the contaminated area until monitored and decontaminated. The area adjacent to the hot line is designated the stepoff pad (SOP) and serves as a boundary zone between contaminated and uncontaminated areas. It is possibly considered to contain some low-level contamination.

Hence, the SOP is often covered with plastic sheeting to facilitate its decontamination.

The procedure for leaving the contaminated area is as follows:

1. Upon leaving the contaminated area:

Remove protective clothing, except shoe covers and gloves.

Discard clothing and trash into appropriate barrels.

2. Stepping onto SOP:

Remove one shoe cover and place foot on SOP.

Repeat for other shoe cover. To prevent spraying the SOP with contamination, the bottom of the foot should be pointed toward the contaminated area when removing shoe cover.

Discard shoe covers in appropriate barrel.

Remove respirator.

Remove gloves and discard in appropriate barrels.

3. While in clean area:

Perform personnel contamination survey.

Remove street clothes.

### **12.4 Personnel Decontamination**

If a person is suspected of being contaminated, he or she should remove their clothing and place it in a plastic bag. Mark it as radioactive and do not discard. Shower thoroughly with water and a liberal amount of soap.

Special instructions for decontamination of various parts of the body are:

- a. Skin - Use a soft bristle brush vigorously but lightly so as not to abrade the skin. Particular attention should be paid to cleaning around and under finger nails, between the fingers, at the back of the fingers and the palms.

b. Hair - Scrub the hair vigorously using a liberal amount of soap. Particular care should be taken to prevent suds and water from entering the eyes, ears, nose or mouth. Several washes and rinses should be applied before drying the hair.

c. After decontamination, individuals should be monitored again. Repeat decontamination procedures if required. If the person still shows contamination, seek medical advice. The basic ground rule is not to abrade or puncture the skin.

## **12.5 Spread of Contamination**

Contamination may be transported or spread to other areas. Radioactivity may be spread via wind or liquid-borne surface runoff from the site. Contamination can be spread by:

1. Resuspension of radioactive particulates that have settled on surfaces because of the movement of personnel and equipment in a contaminated area.
2. Transfer to the shoes, clothing or skin of personnel and transport to uncontaminated areas.
3. Release of contaminated equipment to uncontaminated areas. The ease with which contamination is spread depends upon physical factors (porosity of surface, chemical bonding, electrostatic forces and physical form of the contaminant), meteorological factors, and the effectiveness of contamination control.

## **12.6 Types of Contamination**

Surface contamination may be classified as either fixed or removable. Fixed contamination is measured by passing a suitable detector over the surface of interest as close as possible without actually touching it. Removable contamination is estimated by wiping the surface and measuring the activity on the wipe. Analysis of wipe samples are usually accomplished in a laboratory.

### **12.7 Decontamination of Equipment**

The Radiation Officer will decide either to decontaminate an object or to treat it as radioactive waste. Decontamination might generate a greater volume of radioactive materials (wash water, towels, etc.) than the object itself. Samples of the wash water should be assayed to help determine if it can be released to the environment or if it must be contained for disposal as radioactive waste. Monitoring of the objects determines the extent of decontamination required. Perhaps only limited areas require cleaning. Dry vacuuming may be very effective as an initial step.