



# **University of Notre Dame Radiation Safety Manual**

**Risk Management & Safety  
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## Radiation Safety

### 1. Purpose and Scope

- 1.1 This manual describes methods to keep individual and collective doses of radiation as low as reasonably achievable (ALARA).
- 1.2 This manual applies to all University of Notre Dame personnel who work with radioactive material or radiation producing machines, or work in areas where those items are present.

### 2. Responsibilities

- 2.1 **The Radiation Control Committee (RCC)** shall be appointed by the President of the University. It shall consist of at least eight members, including representatives from the Administration, Risk Management and Safety, and from each of the major areas employing radioactive materials or radiation devices. The Radiation Safety Officer, the representatives from the Office of Research and the office of Risk Management and Safety shall be *ex-officio* members. The representatives from the areas employing radioactive materials shall possess a Ph.D. and have at least five years of experience working with radioactive materials. A license amendment shall be required to change the Chairperson or the Radiation Safety Officer; other RCC members may be changed at the discretion of the President of the University. Duties of the RCC are:
  - 2.1.1 To establish regulations pertaining to the use of radioactive materials and radiation producing devices at the University of Notre Dame.
  - 2.1.2 To receive the reports of the Radiation Safety Officer and to consider additional regulations in accordance with his/her recommendations.
  - 2.1.3 To review and act on applications of individuals who wish to become a Responsible Investigator (RCC Form 1.)
  - 2.1.4 To define the conditions and the requirements for safe use of radioactive materials and radiation producing devices and rule on the suitability of existing and proposed facilities.
  - 2.1.5 To assure the maintenance of adequate records concerning exposure of personnel and the acquisition of radioactive materials.
  - 2.1.6 To review reports of noncompliance with these regulations and to take such action as may be necessary to assure the provisions of these regulations are being met.
  - 2.1.7 To review proposals for field uses (off-campus sites) of radioactive isotopes and to rule on the suitability of such proposals. If the field use proposal is not allowed on the University's Byproduct Material License, an amendment may be submitted to the NRC for approval.
  - 2.1.8 To serve as the University's sole liaison with the Nuclear Regulatory Commission and the Indiana State Board of Health in matters of registration, licensing, and radiological control.

- 2.1.9 To review the radiation protection program at least annually to determine that all activities are being conducted safely and in accordance with the NRC regulations and conditions of the license. The RCC will also review the radiation safety staffing and support allotted to the Risk Management and Safety Department and make a determination as to whether this staffing and support is sufficient to carry out the duties and responsibilities necessary to meet the University license requirements and NRC regulations.
- 2.1.10 To review and approve or disapprove applications from Responsible Investigators for new radionuclides, for additional quantities of radionuclides, new facilities for radioisotope usage, and annually for continued use of radionuclides. (RCC Forms 2, 3, and 4.)
- 2.1.11 To maintain written records of all RCC meetings, actions, recommendations, and decisions.
- 2.1.12 To review training manuals, class outlines, and exams applicable to all categories of Radiation Safety Training.
- 2.1.13 To perform a quarterly review of occupational radiation exposures with particular attention to instances in which the investigational levels of Item 10, Appendix H of the University's NRC Broad Scope License are exceeded (see below).

*The Chairperson of the Radiation Control Committee, the Radiation Safety Officer, and Radiation Safety Specialist are authorized to act (under policies established by the RCC) for the RCC between meetings. Actions taken will be reported to the RCC for review no later than the next scheduled meeting.*

**Investigational Levels**  
**(mrems per two month badging period)**

	Level I	Level II
Whole Body; head and trunk, active blood-forming organs, lens of eye or gonads	80 mrem	240 mrem
Hands and forearms; feet and ankles	1250 mrem	3750 mrem
Skin of whole body	500 mrem	1500 mrem

22 **The Radiation Safety Officer (RSO)** shall be approved by the Radiation Control Committee and shall be a person who has training in radiological health. The responsibilities for the RSO and the RSO's authorized representatives are:



- 2.2.1 To maintain radiation exposures at the lowest reasonably achievable level by the supervision or operation of an effective and appropriate radiation protection program.
- 2.2.2 To maintain a training course in radiation safety for personnel working with radiation.
- 2.2.3 To assure that personnel monitoring devices are used where indicated and that records are kept of the results of such monitoring.
- 2.2.4 To advise all personnel working with radioactive material and radiation producing devices of their annual radiation exposure.
- 2.2.5 To conduct periodic radiation surveys and keep records of such surveys including descriptions of corrective measures.
- 2.2.6 To investigate each case of excessive or abnormal exposure to radiation to determine the cause, and to take steps to prevent its recurrence.
- 2.2.7 To supervise the disposal of radioactive materials and maintain disposal records.
- 2.2.8 To provide consulting services in all aspects of radiation protection.
- 2.2.9 To report interim activities at each meeting of the RCC for their approval of recommendations.
- 2.2.10 To submit to the RCC for their approval or recommendations, all proposals from Responsible Investigators for new uses and/or changes in the use of radioactive isotopes.
- 2.2.11 To maintain a complete inventory of all radioactive isotopes on campus and at off-campus sites to assure that the University remains within its authorized possession.
- 2.2.12 To receive, approve, validate, and record all requisitions submitted by Responsible Investigators prior to being sent to the University Procurement Department.
- 2.2.13 To suspend operations in any facility where it is evident that health hazards exist to the extent of endangering life or property, or to the extent that continued operation would result in violation of existing federal, state, or University regulations. Actions of this nature shall, so far as possible, be a joint decision with the Area Radiation Safety Officer. The RCC shall be advised of any suspension of operations at the earliest possible time.
- 2.2.14 To provide Area Radiation Safety Officers, upon request, records of isotopes, surveys, etc., of Responsible Investigators under their jurisdiction.
- 2.2.15 To examine incoming packages in accordance with 10 CFR 20.1906 and to examine all packages of radioactive material leaving the institution.
- 2.2.16 To perform leak tests on all sealed sources requiring such tests, and maintain records of such tests.
- 2.2.17 To assure compliance with rules, regulations, and permits.
- 2.2.18 To monitor and ensure maintenance is performed on absolute and other special filter systems.
- 2.2.19 To oversee radioactive material storage.

2.2.20 To oversee the instrument calibration program.

2.2.21 To oversee decommissioning, decontamination, and recovery operations.

### 2.3 Area Radiation Safety Officer

One Responsible Investigator within each department or group of departments employing radioactive materials or radiation sources shall be designated the **Area Radiation Safety Officer (ARSO)**. One additional Responsible Investigator with a department having many approved radioactive material users may also be designated an ARSO for that department. These officers will be designated by the RCC after agreement with the department concerned. The responsibilities of the Area Radiation Safety Officer are:

- 2.3.1 To request and receive receipt and disposal records of radioactive material and radiation safety surveys on file at the Risk Management and Safety Office of those RIs, under his/her jurisdiction, at any time he/she may deem it advisable.
- 2.3.2 To conduct radiation safety surveys, contamination checks, and maintain receipt and disposal records of radioactive materials of Responsible Investigators under his/her jurisdiction, if he/she deems it advisable, in addition to his/her option offered in Item 2.3.1 above.
- 2.3.3 To review and maintain radiation exposure records of personnel in his/her area.
- 2.3.4 To act as advisor to Responsible Investigators in ensuring that safe operating practices are followed.
- 2.3.5 To follow emergency procedures as outlined in Section 5 of this Manual in the event of accidents, spills, etc., and to supervise the decontamination of such areas.
- 2.3.6 To suspend operations in any facility under the jurisdiction of the ARSO where it is evident that health hazards exist to the extent of endangering life or property or to the extent that continued operation would result in violation of existing federal, state, or University regulations. Action of this nature shall be called to the attention of the RSO at the earliest possible time.
- 2.3.7 To receive and review reports from the RSO regarding emergencies, corrective actions, and other matters concerning Responsible Investigators and laboratories under his/her jurisdiction.

2.4 **Responsible Investigators (RI)** are faculty members of the University of Notre Dame who make application to the University of Notre Dame and provide evidence of training, experience, and facilities which enable them to work safely with radioactive materials and radiation producing devices. The responsibilities of the RIs are:

- 2.4.1 To comply with all applicable regulations for the safe use of radiation and radioactive materials.
- 2.4.2 To ensure that all users of radiation devices and radioactive materials, working under his/her supervision, comply with all applicable regulations.

- 2.4.3 To instruct the users of radiation devices and radioactive materials, working under his/her supervision, in the safe use of safety devices and procedures.
- 2.4.4 To provide facilities and accept responsibility for the safe use of radioactive materials and radiation devices by individuals under his/her supervision.
- 2.4.5 To limit use of radioactive devices and materials covered in his/her approval as a RI to persons over whom he/she has supervision.
- 2.4.6 To provide adequate planning of experiments and procedures to assure that required safety precautions are taken.
- 2.4.7 To keep the RSO and ARSO informed of new techniques, changes in operational procedures, or in the physical plant which might lead to increased personnel exposure or contamination levels.
- 2.4.8 To initiate orders for needed radioactive isotopes and keep records of the disposal of such materials.
- 2.4.9 To obtain and review exposure records of themselves and of personnel under their supervision.
- 2.4.10 To prepare an inventory of radioactive materials on hand at least annually and at other times when requested by the RSO or the RSO's designee.
- 2.4.11 To notify the ARSO of his/her plans and also of the arrangements made for the handling of radioactive material during his/her absence whenever he/she plans to take sabbatical leave, an extended vacation, or for any reason will be unable to maintain personal supervision or fulfill his/her responsibilities for two or more weeks as contained in these regulations. These arrangements shall be made well in advance of his/her departure. The RI shall also notify the Risk Management and Safety office prior to his/her leaving the campus for any period of two weeks or longer.
- 2.4.12 To advise all female radiation workers of childbearing age verbally and in written form of the increased risk of prenatal radiation exposure. New female employees shall be so advised before beginning work. The appropriate form (RCC Form 8) may be obtained from the Risk Management and Safety office.

## **2.5 Application for Approval as a Responsible Investigator**

- 2.5.1 All individuals wishing designation as RI shall submit the appropriate form (RCC Form 1), properly filled out, directly to the RSO. The application forms may be obtained from the Risk Management and Safety website: <https://riskmanagement.nd.edu/safety/laboratory-safety/radiation-safety/>.
- 2.5.2 The RCC will rule on the qualifications of the individual to handle radioactive materials in a safe manner on the basis of experience, training, and proposed facilities. As a minimum, applicant shall have:
  - A college degree at the bachelor level, or equivalent training and experience, in the physical or biological sciences or in engineering;



- And at least 40 hours of training and experience in the safe handling of radioactive materials, the characteristics of ionizing radiation dose and quantities, radiation detection instrumentation, and biological hazards of exposure to radiation appropriate to the type and forms of byproduct material to be used.
- 2.5.3 A written letter indicating disapproval or approval with the required conditions for use will be returned to the investigator by the RCC. Approvals will be granted for periods of not more than two years, at which time application for renewal of approval shall be submitted to the RCC.
- 2.5.4 If the applicant requests approval to use specialized devices which they have not used previously, such as gas chromatography, x-ray analyzers, irradiators, etc., the RCC will require that the applicant receive the “hands-on” training prior to authorizing such individuals for independent use of licensed material.
- 2.5.5 Under the supervision of the RSO or his/her designee, “hands-on” training will include:
- Instruction of the safe operation and maintenance of the equipment.
  - Instruction on the potential radiation hazards and their effects.
  - A review of the safety interlock system, if any.
  - A review of the radiation monitoring requirements, if any.
  - Instruction on emergency procedure in the event of a real or suspected exposure.
  - The requirement that the applicant successfully operate the unit two times.
  - In addition to the above, the applicant shall be accompanied by the RSO or Radiation Safety Specialist during the first two uses of the specialized equipment.
- 2.5.6 The Chairperson of the RCC, after it is ascertained that the applicant is fully qualified and his/her facilities have been surveyed, and upon the recommendation of the RSO, may grant temporary approval pending official approval by the RCC at the next regular meeting.

## **2.6 Individual Users of Radiation Devices and Radioactive Materials**

No person shall use radioactive material or radiation devices on the Notre Dame campus who has not been appropriately indoctrinated, including initial class and annual review, in the safe use of radioactive materials or radiation producing devices. Only individuals supervised by an RI are allowed to use radioactive material or radiation producing machines. Each person who uses sources of radiation has a responsibility to:

- 2.6.1 Wear the required personnel monitoring devices, film badges, or pocket ionization chambers.
- 2.6.2 Keep his/her exposure at the lowest reasonably achievable value and below the maximum permissible exposure as stated in Section 2.1.13 of these standards.

- 2.6.3 Maintain good housekeeping practices in laboratories.
- 2.6.4 Be aware of work in accordance with government and University regulations concerning the safe use of radiation sources.
- 2.6.5 Monitor himself or herself (hands, feet, and clothing) for contamination each and every time he/she runs a risk of contamination.
- 2.6.6 Use all recommended protective measures. (Refer to Section 4.4 of this manual.)
- 2.6.7 Not smoke, eat, drink, or apply cosmetics in areas where radioactive materials are used, nor store any food or beverage items in such an area.
- 2.6.8 Check working area for contamination after procedures with radioisotopes.
- 2.6.9 Label contaminated equipment and segregate radioactive waste and equipment to avoid cross-contamination.
- 2.6.10 Report immediately to the ARSO or the RSO the details of spills or accidents involving radioactivity.
- 2.6.11 Conduct decontamination procedures in accordance with emergency procedure outlined in the regulations. (See Section 6)
- 2.6.12 Be familiar with, and abide by, information concerning the increased risks of prenatal radiation exposures.
- 2.6.13 Be familiar with, and abide by, requirements for contamination surveys in each lab.
- 2.6.14 Be familiar with, and abide by, requirements for the receipt of packages containing radioactive materials.

### **3. University Regulations Concerning the Use of Radioactive Materials and Sources**

#### **3.1 Radioisotope Procurement**

- 3.1.1 All orders for radioactive material shall be initiated by a RI. The University and the RCC are responsible for all individuals using radioactive material and their subsequent activities; therefore, only individuals approved by the RCC may obtain radioisotopes. No quantity of radioactive material is considered exempt or generally licensed under the University's Byproduct Material License. If the radioactive material is to be acquired from an outside source through Procurement Services, the order shall be designated as "Radioactive" on the E- Procurement order site. The order is then emailed to the RSO, the Radiation Safety Specialist, or their designee in the Risk Management and Safety Department, who will then check the requisition to ensure that the University's possession limits are not exceeded, that the radionuclide and form of the material are authorized on the University's license and that the RI is authorized to possess the radioactive material and quantity ordered. RIs who anticipate receiving samples from suppliers, or any other shipments of radioactive materials for which there will be no purchase order, shall inform Risk Management and Safety as soon as they are aware of it, and instruct the shipper to send the article to University of Notre Dame Central Receiving on Douglas Road.



32 **The receipt, delivery and opening of all incoming radioactive material packages** shall be a function of the Risk Management and Safety (RMS) office. This will allow a timely response by the RMS office in the event a damaged package or incorrect material is received. Procedures outlined below will be followed to ensure these operations are performed safely and timely.

- 3.2.1 All incoming packages containing radioactive material, except for materials with a half-life of less than 13 hours, shall be delivered to University Central Receiving. Central Receiving personnel will contact the RMS office as soon as possible, but no later than 3 hours after receipt of the package. RMS office will be contacted immediately by Central Receiving personnel if the radioactive material package is labeled “perishable”.
- 3.2.2 Materials with half-lives of less than 13 hours shall be delivered directly to the lab in which they are to be used. Laboratory personnel in those labs shall be trained to meet DOT requirements, and shall conduct check-in procedures as directed in sections 3.2.5 through 3.2.7 of this manual.
- 3.2.3 All incoming packages shall be examined in accordance with 10 CFR 20.1906. No packages of radioactive material are to be received after normal working hours.
- 3.2.4 RMS personnel shall pick up the package from Central Receiving, take the package to their RMS Services building and conduct the examination. Sound safety practices shall be followed in all examination practices.
- 3.2.5 The exterior package shall be examined for leakage, contamination, or damage.
- 3.2.6 The contents and quantities of the package listed on the packing slip shall be checked against the requisition for the material. The person checking the package shall immediately contact the lab that placed the order to determine what further action to take.
- 3.2.7 Contamination limits are defined below as well as procedures to follow if the limits are exceeded.
  - If removable radioactive contamination exceeds 22 DPM per square centimeter, or,
  - If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at 3 feet from the external surface in excess of 10 millirem per hour, the RMS office will immediately notify the final delivery carrier by telephone, and facsimile the NRC at:

**U.S. Nuclear Regulatory Commission  
Inspection and Enforcement Office Region III  
2443 Warrenville Road  
Lisle, Illinois 60532-4342  
Phone: 630-829-9500  
Facsimile: 630-515-1259**

- 3.2.8 Results of the examination shall be documented on “Radioactive Material Package Examination Form,” RCC Form 5, and maintained in the RMS office for future reference. The radioactive material will be recorded on the RI’s Inventory.
- 3.2.9 When it is ascertained that the package is not contaminated, the package will be delivered to the user’s laboratory by the RMS personnel.
- 3.2.10 The package, after delivery to the lab, shall again be examined against sections 3.2.5 through 3.2.7 of this manual. Results of the package surveys shall be forwarded to the RSO within one business day.
- 3.2.11 All laboratory personnel receiving packages containing radioactive material shall complete Function Specific Training, stipulated in 49 CFR 172.704, as conducted through RMS.
- 3.2.12 The shipment will be entered into the database at Risk Management and Safety immediately following delivery. Information entered includes RI, radioisotope, activity and date.

### 3.3 Package Security and Delivery

- 3.3.1 Package security and delivery procedures have been briefly discussed above and are defined specifically below:
- All transporters are informed to deliver radioactive material packages, with the exception of those materials identified in Section 3.2.2, to University of Notre Dame Central Receiving which is the designated central receiving and temporary storage location. Transporters shall be informed that deliveries of radioactive material can only be made to the University’s Central Receiving, not to individual laboratories, during normal working hours which are 7:30 a.m. to noon and 1:00 p.m. to 3:30 p.m.
- 3.3.2 Incoming packages of radioactive material will not be accepted during off-duty hours. Security personnel have been instructed not to accept or allow delivery of any package of radioactive material after Central Receiving has closed
- 3.3.3 All packages received by University Central Receiving are processed and secured until pick up by RMS personnel. After normal working hours and on weekends, Central Receiving is locked and checked regularly by University Security personnel.
- 3.3.4 In the event of receipt of damaged radioactive material package, the following measures shall be taken:
- The RMS office shall be notified immediately.
  - The delivery personnel shall be retained until RMS personnel can determine that neither they nor their vehicle are contaminated.
  - If the damaged package must be moved prior to arrival by RMS personnel, Warehouse personnel will don protective gloves and clothing to prevent personal contamination and move the package to a remote secured area.

### 3.3.5 Location of Use

- Radioactive materials are to be used and stored only in those facilities which have been approved by the RSO acting in compliance with the regulations of the RCC.
- Individuals may secure approval to use radioactive materials in new areas by submitting to the RSO a description of the facilities and attesting to the nature of the radioactive materials to be used. The RSO will examine such facilities as described in RCC Form 4 and submit his/her recommendation for approval or disapproval to the RCC.
- Facilities shall have available survey instruments or other types of detection equipment which are appropriate to the type and level of ionizing radiation used.
- Shielding materials shall be available appropriate to the types and levels of radiation in all laboratories. Any stored material shall be shielded so that the dose rate at the surface of the shield does not exceed 5.0 milliroentgen per hour.
- All radioactive material shall be stored in a secured area. All material shall be kept in a locked storage area, or all doors to the lab shall be locked at any time there is no one in that specific laboratory.

## 34 Transfer of Radioisotopes

Prior to conducting a transfer of any radioactive material from or to a radioactive material facility, RIs shall notify the RSO or the Radiation Safety Specialist of the transfer and the transportation arrangements. Procedures that shall be followed for each type of transfer are listed here:

### 3.4.1 Transfer from one area on campus to another area on campus

- RI notifies the RMS office of the following:
  - ◇ Date of transfer
  - ◇ Name of RI receiving the radioactive material.
  - ◇ Radionuclide, chemical form, physical form and quantity to be transferred.
  - ◇ Name of individual transporting the material.
  - ◇ Mode of transportation
  - ◇ Description of the shipping container, how the material will be packaged, type of shielding, if any, and the type of shipping label affixed to the container.

RMS personnel will provide assistance in the proper packaging of the material and labeling of the shipping container.

Once the procedures have been deemed satisfactory, the transfer shall be approved by the RSO or the Radiation Safety Specialist. Records of the transfer will be



maintained in the RMS office. The RI involved in the transfer shall also maintain records of the radioactive material transferred/received in his/her radioisotope log books.

#### 3.4.2 Transfer from Notre Dame to another University or Research Center

- RI notifies the RMS office of the following:
  - ◊ Date of transfer
  - ◊ Name and location of individual receiving the radioactive material.
  - ◊ Radionuclide, chemical and physical form and quantity to be transferred.
  - ◊ Name of individual transporting the material, if known.
  - ◊ Mode of transportation
- Packaging of the radioactive material shall be conducted under the supervision of the RSO or Radiation Safety Specialist to ensure compliance with NRC, DOT, and the carrier's requirements.
- A copy of the receiving institution's Byproduct Material License or Certificate of Authorization shall be on file with the University of Notre Dame's RSO.
- The Notre Dame RSO shall have a notice from the other institution's RSO verifying that the final user is approved for the material and its respective quantity.
- Once all conditions have been met, the transfer shall be approved by the RSO or Radiation Safety Specialist who will maintain records of the transfer.
- The RI transferring the material shall also maintain records of the transfer in his/her radioisotope log book.

#### 3.4.3 Transfer from another University or Research Center to Notre Dame

- RI receiving the radioactive material notifies the RMS office of the following:
  - ◊ Date of transfer
  - ◊ Name and location of institution shipping the material
  - ◊ Radionuclide, chemical and physical form, and quantity to be received
  - ◊ Name of individual transporting the material, if known.
  - ◊ Mode of transportation
- The RI receiving the radioactive material shall be authorized by the RCC to possess and use the material.
- Transporters shall be informed to deliver the package to Central Receiving for normal processing by RMS.
- Once all conditions have been determined to be satisfactory met, the transfer shall be approved by the RSO or the Radiation Safety Specialist who will maintain records of the transfer.
- The RI receiving the material shall also maintain records of the transfer in his/her radioisotope log book.

### 3.5 Use of Radioactive Material at Designated Off-Campus Sites

The RCC has established the following criteria for field use of radioactive material at the University Notre Dame Environmental Research Center (UNDERC) and for other field locations:

#### 3.5.1 Criteria for UNDERC

- Notre Dame faculty members who wish to use radioactive material at the research center shall first apply for and obtain authorization from the RCC to become a RI.
- Researchers outside the University who wish to use radioactive material at the research center shall first apply for and obtain authorization from his/her University's RCC.
- Researcher's shall submit summaries of their proposed project and include the following information:
  - ◇ A complete application describing the radionuclides to be used, the maximum quantity to be used at any one time, the chemical and physical forms of each, the location of use, and training and experience of the individual(s) using the radioactive material.
  - ◇ A complete experimental protocol including:
    - Safety measures to be used in transporting the material
    - The means of preventing unauthorized use or removal of the material at the research center
    - Handling procedures of the radioactive material
  - ◇ A description of the amount of radioactive material to be in the field (if any), and procedures for minimizing any release to the environment.
  - ◇ A description of the expected radiation dose to humans.
  - ◇ The written permission from the Director of UNDERC to use radioactive material at that site.
- Investigators or Researchers shall agree to abide by safety practices set forth in the University of Notre Dame's Radiation Safety Manual and assume full responsibility for the safe use of radioactive material.
- All projects will be reviewed by the RCC and those deemed satisfactory will be submitted by the RCC to the appropriate state health authorities for their review of the application and the authorization. Once the state authorities have approved the project, final authorization will be granted by the RCC. The RCC may require additional conditions for use of the material such as shielding, personnel monitoring devices, a survey meter, or protective clothing.

- An UNDERC RSO will be designated by the RCC when radioactive materials are used or stored at the research center. The responsibilities of the UNDERC RSO are outlined in Section 2.3., ARSO. In addition to these responsibilities, the UNDERC RSO will be required to conduct audits of the research facilities while material is in use as outlined in Section 4.5.
- Should a RI request to use radioactive materials during the off-season, when an ARSO is not on site, the RCC may approve the use if it is determined that the research can be performed safely (does not present any unusual hazards) and that accidents or spills can be managed properly. The RCC may stipulate certain conditions or approval that would require the RI to perform additional responsibilities or task such as more frequent laboratory surveys and closer supervision of students and technicians.

### **3.6 Criteria for Field Use of Radioactive Material at Locations other than UNDERC**

- 3.6.1 Notre Dame faculty who wish to use radioactive material for field studies at locations other than UNDERC shall first apply for and obtain authorization from the RCC to become a RI.
- 3.6.2 Investigators shall submit summaries of their proposed project and include the information as outlined in Section 3.5.1. Permission to use radioactive materials must be obtained in writing from the property owner of the proposed site.
- 3.6.3 Investigators or Researchers shall agree to abide by safety practices set forth in the University of Notre Dame's Radiation Safety Manual and assume full responsibility for the safe use of the radioactive material.
- 3.6.4 All projects will be reviewed by the RCC and those deemed satisfactory will be submitted by the RCC to the appropriate state health authorities for their review of the application and authorization. Once the state authorities have approved the project, final authorization will be granted by the RCC. The RCC may require additional conditions for use of the material such as shielding, personnel monitoring devices, a survey meter and/or protective clothing.



### 3.7 Personnel Monitoring and Bioassays

Personnel monitoring devices appropriate to the type and level of radiation used shall be available and used by all personnel involved with significant levels of ionizing radiation. Federal regulations require the use of such equipment by each individual who enters a restricted area in any calendar year and could receive a dose equivalent in excess of 10% of the maximum permissible dose values as stated in 10CFR 20.1201 - 20.1208. In addition, where the hand dose may exceed 10% of the dose equivalent as stated in 10CFR 20.1201 (a) (2) that person will receive an appropriate hand or finger monitoring device. Film badges and thermoluminescent dosimeter (TLD) rings are changed every two months and furnished by a National Voluntary Lab Accreditation Program (NVLAP) accredited vendor.

3.7.1 Film badges: The instructions concerning the procurement and use of film badges are as follows:

- The RI is responsible for procuring film badges from the RSO for his/her personnel.
- Except as provided in 3.7.1.3 below, film badges shall be worn by personnel working in the following instances:
  - ◊ When working with 1 MeV or greater beta emitters.
  - ◊ When working with gamma emitters of any energy.
  - ◊ When working with neutron sources or neutron generating devices.
  - ◊ When working with x-ray producing devices.
- Film badges need not be worn in cases where it has been definitely established by the RSO that exposures will not exceed the specified limits. This will depend upon the intensity and energy of the radiation and the working conditions involved.
- Film badges to be used for monitoring whole body exposure shall be worn on the torso; e.g. belt, lapel, pocket, etc.
- Extremity film badges or TLD finger rings shall be worn on any extremity likely to receive 10% of the allowable dose equivalent to the extremity.
- Declared pregnant women shall wear a fetal monitoring badge for the entire term of their pregnancy.
- Film badges shall be worn only by the person to whom it is assigned.
- Individual film badge exposure reports are sent to the RSO and the RI every two months. Permanent records of all film badge's exposures will be maintained by the RSO. In any instance where an individual's bimonthly whole body dose equivalent exceeds 240 mrem, the RSO will notify the individual or his/her RI in writing as a means of alerting the individual of such exposure. The RSO will provide all individuals a copy of their permanent occupational exposure history annually and upon written request. Likewise, records of any exposure will be forwarded to new employers upon written request of the individual.

- Film badges or TLD ring badges are obtained through the RMS office. Users shall complete the Request for Film Badge Service Form (RCC Form 6). <https://riskmanagement.nd.edu/safety/laboratory-safety/radiation-safety/>.
- If the user has had previous occupational exposure at another facility, the form “Authorization for Releasing Radiation Exposure” (RCC Form 7) shall be completed and forwarded to the RMS office along with their film badge service request form.

### 3.7.2 Bioassay Program:

To ensure compliance with 10CFR 20.1201 and 20.1502, bioassays to measure possible internal exposures are required for laboratory personnel who use certain radionuclides specified by the RCC (e.g. Tritium ( $^3\text{H}$ ), Iodine 125 ( $^{125}\text{I}$ ), Iodine 131 ( $^{131}\text{I}$ ). In certain quantities, chemical forms and/or chemical reactions, these specified radionuclides pose a potential inhalation and or a skin absorption exposure to users in restricted areas. Their use, therefore, shall be closely monitored to ensure limits specified in 20.1201(a)(1) are not exceeded and that ALARA principles are maintained. In addition, air monitoring will be done in all High Classification labs as defined in Table 3. This monitoring will be done with charcoal tubes or other appropriate monitoring equipment.

This bioassay monitoring program shall establish criteria for the conditions under which in-vivo or in-vitro measurements are necessary, who shall participate, the frequency of measurements, and action levels and corresponding procedures.

Bioassay- Is defined as the determination of the kind, quantity of concentration, and location of radioactive material in the human body by direct (in vivo) measurement or by analysis (in vitro) of materials excreted or removed from the body.

- Tritium:
  - ◇ Conditions under which in-vitro bioassay is necessary:  
Bioassay is necessary when an individual handles in open form of unsealed quantities shown in Table 1. The quantities shown in Table 1 apply to both the quantity handled at any one time or integrated as the total amount of activity introduced into a process by an individual over any one month period.
  - ◇ Participation:  
All personnel handling tritium or sufficiently close to the process so that intake is possible (e.g., within a few meters and in the same room as the workers handling the material) shall participate in the bioassay program.

- ◇ Frequency:  
Urine samples (25 milliliters) shall be obtained from all persons who participate, 24 hours in advance of the experiment, weekly for the duration of the experiment, and 24 hours following the completion of the experiment. Samples may be obtained more frequently at the RSO's discretion. Urine samples will be analyzed in a liquid scintillation counter. Records shall be kept on each worker and the results in uCi/liter shall be plotted against time.
- Action points and corresponding actions:
  - ◇ Whenever the intake of tritium within any 40 hour work period exceeds the amount that would be taken into the body from uniform exposure for 40 hours at the air concentration ( $5 \times 10^{-6}$  uCi/ml) specified in Table 1, Column 1, of Appendix B to 10 CFR Part 20, the licensee is required to make evaluations, take necessary corrective actions, and maintain records as specified in paragraph 20.1702 of 10 CFR Part 20.
  - ◇ If urinary excretion concentrations exceed 5 uCi/L but are less than or equal to 50 uCi/L, the following course of action shall be taken:
    - An investigation of the operations involved, including surveys and monitoring of air and surface and contamination, shall be carried out to determine the causes of the intakes or of the possible involvement of other employees shall be performed.
    - Any reasonable corrective actions that the investigation indicates may lower the potential for further exposures shall be implemented.
    - A repeat urine sample shall be taken within one week after collection. Internal dose commitments shall be estimated using at least two urine sample evaluations and the survey data, including the probable times of the intake of tritium.
  - ◇ Any evidence indicating that further work in the area might result in an employee receiving a dose commitment in excess of the limits established in paragraph 20.1201 of 10CFR Part 20 shall serve as cause to remove the employee from work in this operation until the source of exposure is discovered and corrected.
  - ◇ Reports or notification shall be provided as required by paragraph 20.2203 of 10CFR Part 20 or as required conditions of the license pursuant to paragraph 20.1204 of 10 CFR Part 20.
- If urinary excretion concentrations exceeds 50 uCi/L, the following course of action shall be taken:

- ◇ Carry out all steps in Regulatory Position 5.1.2 of NRC Regulatory Guide 8.32.
- ◇ If the projected dose commitment exceeds levels for the whole body as provided in paragraph 20.2202 of 10CFR Part 20, notify the NRC in the time frame designated in that paragraph.
- ◇ Carry out repeated sampling at approximately one week intervals at least until urine samples show concentrations less than 5 uCi/L. If there is a possibility of long term organic compartments of tritium that require evaluation (see NUREG 0938), continue sampling as long as necessary to ensure that appreciable exposures to these other compartments do not go undetected and to provide estimates of total dose commitments.
- Quarterly Sampling:  
Carry out the actions called for when any of the action levels indication in Regulatory Position 5.1 of NRC Regulatory Guide 8.32 are exceeded. In addition, initiate biweekly (or more frequent) sampling for at least the next six-month period, even when urinary concentrations fall below 5 uCi/L.

**Table 1**

**Activity Levels or Concentrations Above Which Tritium Bioassay Programs Shall Be Provided**

Types of Operation	Volatile or Dispersible	Bound to Non-volatile Agents
Processes in open room or bench with possible escape of tritium from process vessels	10 mCi	100 mCi
Processes with possible escape of tritium carried out within a fume hood of adequate design, face velocity, and performance reliability.	100 mCi	500 mCi

- Iodine 125 and Iodine 131:
  - ◊ Conditions Under Which Bioassay is Necessary
    - Bioassay is necessary when an individual handles in open form of unsealed quantities of radioactive iodine that exceed those shown in Table 2. The quantities shown in Table 2 apply to both the quantity handled at any one time or integrated as the total amount of activity introduced into a process by an employee over a 3 month period.
    - When quantities handled in unsealed form are greater than 10% of Table 2 values, bioassay may still be necessary under certain circumstances. A written justification for not performing such measurements shall be prepared and recorded for subsequent review during NRC inspections whenever bioassay is not performed and the quantities handled exceed 10% of the level in Table 2.



- Participation:  
All personnel handling radioactive iodine or sufficiently close to the process so that intake is possible (e.g., within a few meters and in the same room as the worker handling the material) shall participate in the bioassay program.
- Frequency:
  - ◇ In vivo thyroid scans, which will be performed at the RMS office, shall be obtained from all persons who participate prior to beginning radioactive iodine work, within 72 hours following start of the experiment (but waiting at least 6 hours for distribution of a major part of the iodine of the thyroid) and every 2 weeks, or more frequently thereafter, as long as the condition described in 3.7.2.2 exist. When work with radioactive iodine is on an infrequent basis (less frequently than every 2 weeks), bioassay shall be performed within 10 days of the end of the work period during which radioactive iodine was handled (but not sooner than 6 hours unless emergency actions to obtain an early prognosis and thyroid blocking treatment are appropriate).
  - ◇ The periodic measurement frequency may be changed if action levels are not reached after initial follow-up bioassay. The frequency will be in accordance with Regulatory Position 2.1.2. of the NRC Regulatory Guide 8.9.
- Action Levels and Corresponding Procedures:
  - ◇ Biweekly or more frequent measurements: Whenever the thyroid burden at the time of measurement exceeds 0.12 uCi of  $^{125}\text{I}$  or 0.04 uCi of  $^{131}\text{I}$ , the following actions shall be taken:
    - An investigation of the operations involved will be carried out to determine the cause of exposure and to evaluate the potential for further exposures.
    - If the investigation indicates that further work in the area might result in exposure of a worker to concentrations that would cause the limiting intakes established in paragraph 20.1201 of 10CFR Part 20 to be exceeded, the worker shall be restricted from further exposure until the source of exposure is discovered and corrected.
    - Corrective actions that will eliminate or lower the potential for further exposures shall be implemented.



- A repeat bioassay shall be taken within 2 weeks of the previous measurement and evaluated to confirm the presence of internal radioiodine and to obtain an estimate of its effective half-life for use in estimating dose commitment.
- Reports of notification shall be provided as required by paragraph 20.2203 of 10 CFR Part 20.
- ◇ If the thyroid burden at any time exceeds 0.4 uCi of  $^{125}\text{I}$  or 0.3 uCi of  $^{131}\text{I}$ , the following actions shall be taken:
  - Carry out all steps described under “Biweekly or more frequent measurements”.
  - As soon as possible, refer the case to the Nuclear Medicine Department, Memorial Hospital, South Bend, Indiana for recommendations regarding the therapeutic procedures that may be carried out to accelerate removal of radioactive iodine from the body.
  - Carry out repeated measurement at approximately one week intervals at least until the thyroid burden is less than 0.4 uCi of  $^{125}\text{I}$  or 0.03 uCi of  $^{131}\text{I}$ .

**Table 2**
**Activity Levels Above Which Bioassay for <sup>125</sup>I or <sup>131</sup>I is Necessary**

<b>Activity Handle in Unsealed Form Making Bioassay Necessary*</b>		
<b>Types of Operations</b>	<b>Volatile or Dispersible*</b>	<b>Bound to Nonvolatile Agent*</b>
Processed in open room or bench, with possible escape for iodine from process vessels.	1 mCi	10 mCi
Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity, and performance reliability.	10 mCi	100 mCi
Processes carried out in within Glove boxes, ordinarily closed, But with possible release of iodine Process and occasional exposure to contaminated box and box leakage.	100 mCi	100 mCi

\* Quantities may be considered the cumulative amount in process handled by a worker during a 3-month period; e.g., the total quantity introduced into a chemical or a physical process over 3-month period, or on one or more occasions in that period, by opening stock reagent containers from which radioactive iodine may escape. Quantities in the right-hand column may be used when it can be shown that activity in process is always chemically bound and processed in such a manner that <sup>125</sup>I or <sup>131</sup>I will remain in nonvolatile form and diluted to concentration less than 0.1 mCi/mg of nonvolatile agent.





*Capsules (such as gelatin capsules given to patients for diagnostic tests) may be considered to contain the radioiodine in non-free form, and bioassay would not be necessary unless a capsule were inadvertently opened (e.g., dropped and crushed). However, certain compounds where radioiodine is normally bound are known to release radioiodine when the material is in process, and the left-hand column may then be applicable. In those laboratories working only with  $^{125}\text{I}$  in radioimmunoassay (RIA) kits, the working quantities of  $^{125}\text{I}$  are very small and in less volatile forms; thus, bioassay requirements may be judged from the right-hand column. In field operations, where reagent containers are opened outdoors for simple operations such as pouring liquid solutions, Table 2 does not apply; bioassay shall be performed whenever an individual employee handles in open form (e.g., an open bottle or container) more than 50 mCi at any one time.*

Operations involving the routine use of  $^{125}\text{I}$  or  $^{131}\text{I}$  in an open room or bench are discouraged. Whenever practicable, sealed bottles or containers holding more than 0.1 mCi of  $^{125}\text{I}$  or  $^{131}\text{I}$  shall be opened at least initially within hoods having adequate face velocities of 0.5 m/sec (80 feet/minute) or more.

Bioassay may be required for other radionuclides if the chemical or physical form or procedures and equipment used make it likely that radioactive material will be ingested, inhaled or absorbed into the body. The RCC will review each experiment that may require bioassays and determine the appropriate action.

#### **4. Rules for the Safe Handling of Radioactive Material**

##### **4.1 Posting of Areas and Containers**

The RMS office shall assume responsibility for providing and posting appropriate radiation caution signs in areas where radioactive materials are used or stored. It is the responsibility of the RI to notify the RMS office whenever radioactive caution signs are damaged or missing so that they may be replaced. Minimum posting requirements are as follows:

- 4.1.1 Each area or room in which NRC licensed material is used or stored and which contains any radioactive material in an amount which exceeds 10 times the quantity of such material specified in Appendix C of 10CFR 20 (Table 4) shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words "Caution Radioactive Materials".
- 4.1.2 Each area in which there exists radiation such that a major portion of the body of an individual in that area could receive a dose equivalent in excess of 100 mrem, in any one hour, shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "Caution High Radiation Area".



- 4.1.3 Each area in which there exists radiation such that a major portion of the body of an individual in that area could receive a dose equivalent of 5 mrem, in any one hour, at 30 cm from the radiation source shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "Caution Radiation Area."
- 4.1.4 Each area or room in which there exists airborne radioactivity composed wholly or partly of NRC licensed material in excess of the derived air concentrations (DAC) specified in Appendix B of 20.1001 - 20.2401 or to such an equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of that annual limit on intake or percent of that annual limit on intake or 12 DAC-hours be conspicuously posted by a sign or signs bearing the radiation symbol and the words "Caution Airborne Radioactivity Area".
- 4.1.5 Each area posted with one of the above caution signs is to be considered a restricted area or area to which access is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. Restricted areas shall be secured when left unattended. The RSO may implement more stringent posting requirement if deemed necessary.
- 4.1.6 Each container in which radioactive material is transported, stored, or used in quantities exceeding the amounts listed in Appendix C of 10 CFR 20 shall bear a durable, clearly visible label with the Radiation symbol and the words "Caution Radioactive Material".
- 4.1.7 Notice to Employees – Federal regulations require that form NRC-3 "Notice to Employees" shall be posted by each licensee whenever individuals work frequently in any portion of a restricted area. This form states that current copies of the following documents are available for review at the RMS office:
- The regulations of Part 19 and 20 of Title 10, Code of Federal Regulations.
  - University of Notre Dame licenses, conditions, and various references incorporated therein.
  - The operating procedures applicable to licensed activities.
  - Notice of violations, proposed civil penalty, or order and any response from the licensee.



## 4.2 Radionuclide Laboratory Classification

Classifications are based on three factors: (1) Relative radiotoxicity of the nuclide in use, (2) Maximum amounts of activity stored or used in the area, and (3) Type of use in terms of the relative hazard of the handling procedures.

- 4.2.1 Radiotoxicity is used to indicate the relative hazard of internally deposited radionuclides. The radiotoxicity depends on the effective half-life of the nuclide in the body or organ, the type and energy of emitted radiation, the chemical and physical form of the material, and the organ in which the material concentrates. Based on these considerations, the relative toxicity of selected nuclides is given in Table 3.
- 4.2.2 Laboratories are then classified according to the total activity of the various nuclides present in the lab. Table 3 gives the three laboratory classifications (high, intermediate, and low) based on radiotoxicity group and activity present. In case of more than one nuclide in use, the laboratory classification will be determined by summing of the constituent nuclides.
- 4.2.3 The amount of a nuclide permitted in a given laboratory classification may be increased or decreased according to the type of usage. For operations having high accident risk, the amount permitted within a classification may be decreased. As a guide, the modifying factors of Table 3 are used to determine the amount by which the permitted activity shall be increased or decreased.



**Table 3**

**Classification of Laboratories\***

**Section 1: Relative Radiotoxicity**

<b>Hazard Class</b>	<b>Description</b>	<b>Examples</b>
I	Very high radiotoxicity	<sup>210</sup> Po, <sup>226</sup> Ra, <sup>237</sup> Np, <sup>241</sup> Am, <sup>244</sup> Cm
II	High radiotoxicity	<sup>22</sup> Na, <sup>36</sup> Cl, <sup>45</sup> Ca, <sup>60</sup> Co, <sup>90</sup> Sr, <sup>106</sup> Ru, <sup>125</sup> I, <sup>131</sup> I, <sup>137</sup> Cs
III	Moderate radiotoxicity	<sup>14</sup> C, <sup>18</sup> F, <sup>32</sup> P, <sup>35</sup> S, <sup>51</sup> Cr, <sup>55</sup> Fe, <sup>57</sup> Co, <sup>59</sup> Ni, <sup>55</sup> Fe
IV	Low radiotoxicity	<sup>3</sup> H, <sup>99m</sup> Tc, <sup>232</sup> Th, <sup>238</sup> U

**Section 2: Classification of Radionuclide Laboratories**

<b>Hazard Class</b>	<b>High Greater than:</b>	<b>Intermediate</b>	<b>Low Less than:</b>
I	1mCi	10 uCi to 1mCi	10uCi
II	100 mCi	1mCi to 100mCi	1mCi
III	10Ci	100mCi to 10Ci	100mCi
IV	1000Ci	10Ci to 1000Ci	10Ci

**Section 3: Modifying Factors for Classification of Radionuclide Laboratories**

<b>Use</b>	<b>Modifying Factor</b>
Storage only	x100
Simple wet operations	x10
Normal chemical operations	x1
Complex chemical operation with high spill risk	x0.1
Simple dry operations	x0.1
Exposure of non-occupational persons	x0.01
Dry dusty operations	

\*NCRP Report 30, Safe Handling of Radioactive Materials, 1964, pp. 11-15



**Table 4:**

**Survey Frequencies**

<b>Classification</b>	
Low	Not less than once per month
Medium	Not less than once per week
High	Not less than once per normal working day

For example: A laboratory has a maximum possession of 5mCi for both  $^3\text{H}$  and  $^{32}\text{P}$ , (Toxicity Class IV and Class III), and conducts simple wet operations (Modifying Factor = x10.) This lab would be a Class III, Low Hazard, and, as such, would require contamination surveys at least once in every month that a radionuclide is used.

**4.3 Maximum Permissible Dose Limits**

Any radiation exposure is undesirable; thus, it is important that all exposures be kept as low as reasonably achievable (ALARA).

All users of radioactive material must make every effort to keep their exposures to a minimum. In restricted areas, control must be such that no individual 18 years of age or older will receive a dose in excess of the following:

- Whole body; head and trunk; active blood-forming organ or gonads - 5.0 Rem/year
- Lens of the eye - 15.0 Rem/year
- Hands and forearms; feet and ankles - 50.0 Rem/year
- Skin of the whole body - 50.0 Rem/year

Individuals younger than 18 years of age shall not receive a whole body dose greater than 500 mrem in one year.

The maximum whole body dose equivalent to women, who have declared, in writing, their pregnancy to RMS, shall be limited to 0.5 rem during the entire gestation period.

Women of childbearing age desiring to use radioactive material shall read NRC Reg. Guide 8.13, Instruction Concerning Prenatal Radiation Exposure, discuss the topic with their RI, sign the form attached to the Reg. Guide (RCC Form 8), and return it to the RMS office.



#### 4.4 Handling of Radioactive Material

Each RI shall enforce compliance with the following regulations and procedures by all personnel under her/his supervision. For purposes of this section a radioisotope laboratory shall be a delineated area in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C to Part 20.

##### 4.4.1 Protection Rules - Personal Contamination

- Before any work is undertaken with quantities of radionuclides which may produce significant external or internal exposure, attention shall be given by the user about precautionary measures including the use of hoods, remote handling equipment, and monitoring. Significant exposure is 10% of the Maximum Permissible Dose.
- Work shall be planned carefully to minimize any chance of spilling radioactive materials. Good housekeeping is encouraged at all times.
- Smoking, drinking, eating, applying of cosmetics and storing or preparation of food is prohibited in radioisotope laboratories.
- No radioactive materials shall be pipetted by mouth. Automatic pipetting devices or rubber bulbs shall be used.
- Personnel are not permitted to work with radioisotopes if there are open cuts or abrasions on exposed areas of the body. Extreme precautions shall be taken to avoid cuts or puncture wounds. This is especially true when working with radioisotopes in Classes I and II (highly toxic) and when working at intermediate and high levels of radioactivity (see Table 3).
- Care shall be exercised when using organic chemicals to avoid skin contact with radioactive materials. (Solvents may make the skin more permeable.)
- Laboratory coats shall be worn when handling containers of radioactive material. These coats shall not be worn outside of the lab.
- Rubber or plastic disposable gloves shall be worn when handling containers of radioactive material.
- Monitoring equipment shall be available and operational at all times and used frequently during and following work to determine the presence of activity and contamination on hands, clothing and facilities. Each user is personally responsible to check himself/herself (hands, feet, and clothing) for contamination each and every time he/she has run a risk of contamination, and before leaving the area.



- Personnel monitoring devices, which will be issued by the RMS office in accordance with Section 3.7 of this manual, will be worn at all times when working with radionuclides in the laboratory. In the event that a non-monitored worker has cause to believe he/she has received a radiation dose, the RMS office will perform a dose calculation based on the energy, type of radiation, length of exposure, and distance from the source the worker is believed to have been exposed.
- Eye protection (either goggles or safety glasses) shall be worn by individuals working with non-solid forms of radioactive material. Goggles are required when using 1.0 mCi of  $^{32}\text{P}$  or when work involves a splash hazard.
- Dispose of radioactive waste only in designated, labeled, and properly shielded receptacles.
- Secure all material when it is not under the constant surveillance and immediate control of the user(s). If constant surveillance cannot be maintained, all radioactive material shall either be locked in a storage facility, or must be housed in a locked room with access granted only to approved users.

#### 4.4.2 Protective Rules - Contamination of Laboratory Equipment, Glassware and Surfaces

- Handling tools and equipment when used and considered contaminated, shall be placed in non-porous metal trays or pans, which are located off to one side, away from the actual working place. It is desirable to line such trays and pans with absorbent disposable paper, which is changed frequently. These papers shall be regarded as radioactive waste only when surveys indicate activity above background or when known contamination occurs.
- Auxiliary containers, absorbent paper, and container lids or stoppers shall always be used where danger of spills and contamination of the user or equipment is possible. (All groups and levels.)
- A caution label or sticker shall be affixed on all containers and equipment that are contaminated with radioactivity until cleaning can be performed. These labels or stickers are available from commercial suppliers.
- Removable contamination shall not be allowed to remain on floors, bench tops, or other facilities (e.g., refrigerators, hoods, etc.). Where floors are known or suspected of being contaminated, the area involved shall be immediately restricted to further traffic and designated as a shoe cover area until such time as it is shown to be free of removable contamination. When



bench tops or other equipment are known to be contaminated, cleaning shall be undertaken immediately until it is shown to be free of removable contamination.

- For the purpose of this rule and with the exceptions of the nuclides listed below, removable contamination is taken to mean removable amounts of beta-gamma activity greater than 1000 decays per minute above background or alpha activity greater than 20 dpm above background as determined by a standard test on surface of 100 square centimeters.  
 $^{125}\text{I}$ ,  $^{129}\text{I}$ : greater than 20 dpm/100 cm<sup>2</sup>.  
 $^{126}\text{I}$ ,  $^{131}\text{I}$ : no more than 200 dpm/100 cm<sup>2</sup>.

#### 4.4.3 Protective Rules - Contamination of Clothing

The rules for prevention of clothing contamination are:

- It shall be the responsibility of the individual and his/her supervisor to see that appropriate protective clothing is worn whenever contamination is possible.
- Protective clothing worn in radioactive areas shall be monitored routinely each day, or when the work with radioactive materials is finished.
- Coveralls, laboratory coat or other protective garments worn in the laboratory are not to be worn outside of the lab where the radioactive material work is conducted.
- Contaminated clothing shall not be worn in clean areas. Articles which show contamination shall be left in the work area, or other designated areas provided for this purpose. Such clothing shall be marked by the user with her/his name, the date, and the nature and degree of contamination and held for storage until the activity has decayed to a safe level, been decontaminated if possible, or disposed of in the proper manner.

#### 4.4.4 Protective Rules - Animals Containing Radioactive Materials

- The RI shall provide a detailed discussion of probable routes of distribution, metabolism, and excretion.
- Injections of radioactive materials in animals shall be carried out in trays lined with absorbent paper. Disposable gloves shall be worn by the worker for all levels of radioactivity.
- All cages housing animals injected with radioactive materials shall be clearly marked as follows:
  - ◇ Name of radionuclide
  - ◇ Amount of radioactive material injected per animal





- ◇ Date of injection
- ◇ RI's name
- ◇ "Caution Radioactive Material" tape be affixed to the cage
- Animals containing radioactive material shall be kept in cages apart from other animals.
- The RSO shall be consulted for determining the proper procedures for cleaning animal's quarters.
- The disposal of solid and liquid radioactive waste shall be provided for and shall follow the procedures outlined in Section 6, Radioactive Waste Storage and Disposal.
- Radioactive animal carcasses and excreta are to be wrapped in plastic bags by the user. The bags shall be labeled properly and then transported to the designed freezers for storage.

#### 4.4.5 Precautions Required in the Use of Alpha Emitting Isotopes

The principal hazard in the case of alpha sources does not come from external penetration of radiation but from radioactive material that may get into the body. Alpha particles with energy less than 7 MeV (and beta of energy less than 70 KeV) have a range of less than 0.07 mm in skin and therefore would not penetrate the epidermal layer of skin. The danger in the use of alpha and beta emitting isotopes comes from the material that may become fixed in the body by ingestion, inhalation, through open wounds, or directly through the skin. Alpha emitters are especially hazardous when fixed inside the body; they dissipate their energy over a short range in tissue with consequent large energy absorption per gram of tissue.

Due to these considerations, special care and attention shall be used in work with alpha emitters. The precautions listed below are necessary in order to minimize the chances of the alpha emitting isotopes becoming fixed in the body:

- All the rules mentioned in the above sections on safe handling and the additional procedures below shall be followed.
- Gloves shall always be worn when working with alpha emitters. They shall be the disposable variety and shall be replaced with a clean pair if any contamination occurs to prevent unnecessary spread of contamination to tools, knobs, etc. The surgical technique for putting on and taking off gloves shall be used to prevent spread of contamination (see RSO for instruction in this technique if necessary).



- A lab coat is also necessary to prevent contamination of clothing and arms. It shall also be replaced if contaminated and its disposal controlled as radioactive. The lab coat shall not be worn outside the area of radioactive usage.
- A properly functioning alpha survey meter shall be in use throughout the procedure to check for contamination of gloves, protective clothing, surfaces, etc. Upon completion of the procedure, the experimenter and the surrounding area shall be carefully surveyed. It is important to allow sufficient response time for the meter to accurately determine any spots of contamination.
- The laboratories and hoods used for alpha work shall be kept as free of dust as possible so the radionuclides do not become airborne by being absorbed on dust and then become transported to the lung.
- The exposed surfaces of the body, especially the hands, shall be thoroughly washed immediately upon completion of work with an alpha emitting isotope.
- Polonium-210 sources shall be kept and used in their containers in their respective hoods at all times unless the RSO approves and supervises their transfer. Before use of the sources, the hoods shall be checked to be sure that no contaminated air could escape from the hood under various operating conditions.
- All alpha sealed sources of activities greater than 10 uCi shall be leak tested once every three months while in use and shall not be put into use after a period of storage exceeding three months without first having a leak test made.

#### 4.4.6 Emergency Procedures– Alpha Emitters

In the case of a spill involving alpha emitters, the main concern is the prevention of airborne contamination.

- If the spill is confined to the hood, close the hood to prevent contamination of the room; shut off the room's circulation to prevent any spread of airborne contamination to the rest of the building.
- Do not leave the vicinity in search of help. Keep the area sealed off from others. Call the RI involved and the RSO.
- If a floor area is involved, shoe covers will be necessary to avoid spread of contamination by foot. Temporary ones can be made using paper or plastic bags.

- It may be necessary to seal off the room completely with tape, etc. until an air sample can be taken to determine the extent of airborne contamination.
- 4.4.7 Precautions Required in the Use of High Energy Beta Emitters Such as  $^{32}\text{P}$ .  
Due to the energy level of these emitters, special safety precautions are necessary to reduce radiation exposure to the user and others who may be working in the laboratory. As with all radionuclides, the potential for radiation exposure increases with the quantity of radioactive material used. Therefore, increased safety precautions are necessary as increased amounts of high energy beta emitters are used. These safety precautions for the different quantities of use are as follows:
- Use of 0 to 250 uCi of High Energy Beta Emitters
    - ◇ Follow all applicable safe-handling precautions as described in Section 4 of this manual.
  - Use of 250 uCi to 1.0 mCi of High Energy Beta Emitters
    - ◇ Follow all applicable precautions in Section 4.4.1
    - ◇ Perform a dry run prior to conducting a new or unfamiliar procedure to preclude unexpected complications. In addition, contact the RSO or the Radiation Safety Specialist and inform him/her of your intentions to conduct a new procedure.
    - ◇ Obtain and wear a finger type extremity monitor (ring badge).
    - ◇ Use a low density shield, such as Plexiglas, in order to minimize production of, and exposure to, Bremsstrahlung radiation.
  - Use of more than 1.0 mCi of High Energy Beta Emitters
    - ◇ Follow all precautions in 4.4.7.1 and 4.4.7.2 above.
    - ◇ Obtain and wear laboratory safety goggles.
    - ◇ Perform a radiation survey and wipe test of the experimental area after each use. Survey results shall be documented on the "Radiation User Inspection Report" form, RCC Form 9, and maintained in the Radioisotope Log Book.

## 4.5 Laboratory Surveys

### 4.5.1 Portable Geiger-Mueller (G-M) Survey Meters

Investigators using quantities of radioactive material which could give rise to exposure to the whole body, skin of the whole body or extremities in excess of 10% of the annual dose equivalent limits are required to have a calibrated and properly operating survey instrument in the laboratory when using these radioactive materials. The survey meter shall be capable of detecting 0.05 uCi of the radionuclide in question.



- Before each use of survey meter, the user shall confirm that the instrument is operating properly by holding the probe or instrument next to a radiation check source or known radiation source. If the instrument does not respond to the radiation, the user shall contact the RMS office for repair.
- The survey meter shall be used frequently during and following work with radioactive materials to determine the presence of radioactivity on working surfaces, the body and clothing.
- All survey meters used routinely in the radiation safety program shall be calibrated at least annually by the RMS office. In addition, the RMS office will recalibrate survey meters after maintenance and repair. Records will be kept of all calibrations.

#### 4.5.2 Laboratory Survey Procedures

- Unsealed Radioactive Material Use
  - ◇ All radioactive laboratories using unsealed sources of radioactive materials and all waste storage facilities will be surveyed by a representative of the RMS office bimonthly (every other month). Radioisotope labs are defined as areas requiring posting of signs as required by CFR 20.1902 (e): "...area or room in which there is used or stored an amount of licensed material exceeding 10 times the quantity of such material specified in Appendix C to Part 20..."
  - ◇ The Laboratory Survey Report Form (RCC Form 10) will be used as a guide in performing the survey. Swipe survey shall be recorded on or attached to the Survey Report Form. Any survey meter reading shall also be recorded on the Survey Report Form. The laboratory log book will be reviewed to determine that quantities of isotopes used, waste records, and laboratory survey records are up-to-date. Deficiencies will be noted on the laboratory survey form. The RMS representative will also list all radioactive materials users and check these names against the current training files. Anyone not attending a Radiation Safety Class or Review Session in the past year shall be removed from radioactive material work until they attend a session.
  - ◇ Laboratories in the High Classification (Table 3) will be surveyed on a monthly basis by a representative of the RMS staff.
  - ◇ Unrestricted areas adjacent to the restricted area will be surveyed (refer to 4.5.2 above for swipe and meter methods) every calendar quarter. The areas will include the hallway floor outside of the lab, knobs, and handles on nearest doors, and restroom facilities closest



to the lab. Results will be recorded on a lab survey form and maintained in a specific building file.

- ◇ All radioisotope laboratories selectively using unsealed sources of radioactive material shall be surveyed by a radiation user designated by the RI once a month and at the conclusion of an experiment. Survey results shall be documented on the form "Radiation User Inspection Report," RCC Form 9, and maintained in their radioisotope log book.
- ◇ Radioactive material users who use more than 1.0 mCi of any unsealed beta emitter with an energy greater than 1.0 mCi, transuranics, or any radioisotope of iodine, shall conduct a survey as soon as practicable following the experiment.
- Sealed Sources of Radioactive Material
  - ◇ All sealed sources containing radioactive material other than  $^3\text{H}$ , 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, except that each source designed for the purpose of emitting alpha particles shall be tested at intervals not to exceed three months.
  - ◇ Sources containing no more than 100 microcuries of beta and/or gamma emitting material, or not more than 10 microcuries of alpha emitting material, need not be leak tested.
  - ◇ Leak tests will be performed by the RMS office. Records will be kept of the survey results. If a sealed source is damaged or appears to be damaged, the RSO or Radiation Safety Specialist shall be contacted immediately.
- Action Levels

Action levels will be based upon Table N-1 of Regulatory Guide 10.8. If a swipe test of an area of 100 cm<sup>2</sup> indicates removable contamination above 1000 DPM in a restricted area or 100 DPM in an unrestricted area, the RI will be notified in writing. The RI shall immediately begin decontamination (RMS personnel will be available for assistance), and the area will be resurveyed. Continued contamination incidents will be cause for the RCC to revoke radionuclide use approval for a RI. If removable contamination exceeds 20,000 DPM on a standard smear of 100 cm<sup>2</sup> of surface area, RMS personnel will immediately take measures to control the area and initiate decontamination procedures. Decontamination will continue until radiation



levels are below the action level of 1000 DPM above background. Depending upon the radionuclide, amount used and experimental protocol, bioassays may be required from users to measure possible internal exposure.

#### 4.6 Radioactive Waste Storage and Disposal

##### WASTE MINIMIZATION STATEMENT

Minimization is an important part of Notre Dame's Waste Management Program. Many RIs have changed their protocols so that the bulk of their work involves short half-lived radionuclides. The importance of waste minimization is stressed during the portions of the training sessions that cover Waste Management.

Low-level radioactive waste generated in the laboratory shall be stored and disposed of in a manner dictated by the Federal government and the University of Notre Dame.

Radioactive waste produced at the University is categorized into nine groups. Each group is disposed of differently and, therefore, shall be stored separately in the laboratory. These nine groups are:

##### Solid Waste (i.e., paper, glass, pipettes, gloves, etc.)

- Long half-life ( $T-1/2$ ) waste, greater than 89 day  $T-1/2$ . (i.e.  $^3\text{H}$ ,  $^{14}\text{C}$ ,  $^{22}\text{Na}$ ,  $^{57}\text{Co}$ , etc.)
- Short half-life ( $T-1/2$ ) waste, less than 89 day  $T-1/2$  (i.e.,  $^{32}\text{P}$ ,  $^{51}\text{Cr}$ ,  $^{125}\text{I}$ , etc.)

##### Liquid Waste

- Aqueous - All radionuclides combined regardless of  $T-1/2$
- Organic -  $^3\text{H}$  and  $^{14}\text{C}$  only (scintillation fluid)
- Organic - Solvents containing radionuclides other than  $^3\text{H}$  and  $^{14}\text{C}$

##### Vials Containing up to 20 mL or Liquids (Scintillation Vials)

- Vials containing  $^3\text{H}$  and  $^{14}\text{C}$  only
- Vials containing radionuclides other than  $^3\text{H}$  and  $^{14}\text{C}$



#### Animal Carcasses, Biological Tissues, etc.

- Tissues containing  $^3\text{H}$  and  $^{14}\text{C}$  only
- Tissues containing radionuclides other than  $^3\text{H}$  and  $^{14}\text{C}$

#### 4.6.1 Waste Storage

- Each lab that produces one or more of the waste types listed above shall have a separate container or designated storage area for each type of waste. Each radioactive waste type should not be mixed if at all possible.
- For solid waste storage containers, a disposable liner shall be used to prevent the container from becoming contaminated.
- Liquid waste shall be stored in non-breakable containers, preferably in polyethylene safety containers. There shall be no possibility of a chemical explosion or chemical reaction during storage that might cause release of radioactive gases or vapors. Liquids shall be neutralized before deposition in a waste container. Liquid waste containers in the laboratories shall be checked frequently for leakage or signs of leakage.
- Radioactive waste shall be stored only in restricted areas where they can be secured against unauthorized removal.
- When radioactive material is stored in a laboratory facility, it shall be shielded such that the exposure rate at the surface does not exceed 5.0 mR/hr.
- All radioactive waste containers shall be conspicuously posted with an appropriate radiation caution sign.

#### 4.6.2 Disposal of Radioactive Waste

No radioactive waste shall be disposed of directly into the sanitary sewer system, into the atmosphere, or into regular trash containers unless permission is granted for this practice by the RSO and/or the RCC. Any accidental release of activity into the environment shall be reported immediately to the RSO. Records of amounts disposed shall be maintained by the RI. Radioactive waste will be picked up on a regular schedule by RMS.

- Solid Dry Waste
  - ◇ Solid dry waste shall be placed in plastic bags and labeled with the radioisotope present and activities (uCi or mCi) of each.
- Liquid Waste
  - ◇ All liquid waste shall be placed in containers furnished by RMS.

- ◇ All aqueous radioactive waste shall be placed in the white five-gallon carboys furnished by the RMS Department. Radioisotopes and quantities shall be entered on the record of deposition tag attached to each container.
- ◇ Organic radioactive waste shall be placed in the red, two or five gallon carboys furnished by the RMS Department. Radioisotopes and quantities shall be entered on the record of deposition tag attached to each container. Organic radioactive waste containing  $^3\text{H}$  and/or  $^{14}\text{C}$  only shall be in containers separate from organic radioactive waste containing other radionuclides.
- ◇ Vials containing  $^3\text{H}$  and/or  $^{14}\text{C}$  only should be kept separate from vials containing radionuclides other than  $^3\text{H}$  or  $^{14}\text{C}$ . Vials should be placed in their original boxes for storage. An indication of the radioisotope(s) and quantities shall then be marked on each box before the boxes can be picked up for disposal. Plastic vials and cellophane bags containing scintillation fluid shall be placed in plastic bags and sealed. Each bag shall be labeled as indicated above before the RMS Department will pick them up for disposal.
- ◇ Waste biological tissues shall be placed in plastic bags, sealed, and sorted in the laboratory freezer. The radionuclides and quantities present in each bag shall be marked on the outside of every bag.

#### 4.6.2 Disposal Methods

- Solid, long half-lived radioactive waste and scintillation vials are transferred to an approved and licensed vendor for transportation, further processing and ultimate disposal in licensed low-level radioactive waste disposal sites or licensed incinerators.
- Disposal of aqueous radioactive waste will be by release into sanitary sewer in conformance with section 20.2003 of 10 CFR Part 20. The release occurs at only one sink, located in the RMS Services Building. Aqueous waste is that waste which meets the solubility criteria of 10 CFR 20.2003 (a) (1). Solubility determination will be made directly from common literature, such as the Handbook of Chemistry and Physics. Components of each liquid waste container shall be listed in the Comments section of the OnBase request for waste pick-up by the radioactive material user preparing the request.
- The University shall not possess, use or transfer licensed material so as to cause the total effective dose equivalent to the individual members of the public to exceed the limits specified in 10 CFR 20.1301, nor shall it possess,





use or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceeds the limits specified in Appendix B Table II of 10 CFR 20. As indicated in Section 20.1302, concentration of radioactive materials in effluents to unrestricted areas, may be averaged over a period not greater than one year.

- Every reasonable effort will be made to minimize the radioactivity contained in the effluents to unrestricted areas. Minimization efforts may include decay in-storage before release, and in line chemical traps or activated charcoal filters.
  - ◇ Water - Release of radioactivity in water shall be closely controlled by the RMS office. At this time, disposal of radioactivity into the University's sanitary sewer is the only water release operation approved by the RCC. This disposal operation is described above.
  - ◇ Air - Release of radioactivity in air shall also be closely controlled by the RMS office. Experiments that may release volatile or gaseous radioactive materials, such as protein iodinations and tritium labeling shall be conducted in fume hoods approved by the RSO or Radiation Safety Specialist. Concentration of radioactive material released in air will be calculated using the "Reporting Form for Radioactivity in Air Concentration to Unrestricted Areas" (RCC Form 11). These calculations will be made to ensure concentrations released do not exceed limits specified in Appendix B, Table II, 10 CFR 20.
- No radioactive material will be treated or disposed of by incineration on campus, or by unlicensed radioactive waste disposal companies.
- Dry solid long half-life radioactive waste will be compacted within a 55 gallon drum with an electric trash compactor, or placed un-compacted in fiberboard boxes, then held until a vendor can ship to a licensed waste disposal facility.
- Disposal without regard to the radioactivity of  $^3\text{H}$  and  $^{14}\text{C}$  contained in scintillation-counting media concentrations of 0.05 microcurie or less per gram, will be performed, subject to certain restrictions stated in section 20.2005 of 10 CFR Part 20.
- Dry-solid radioactive material with a physical half-life of less than 90 days will be held for decay-in-storage before disposal in ordinary trash. This waste will not include biologic, flammable, mixed hazardous, corrosive, or pathogenic waste.



- ◇ The radioactive waste disposed of in this state shall be monitored with a G-M survey meter to determine that its radioactivity cannot be distinguished from background with typical low-level laboratory survey instruments. All radioactive labels will be removed or obliterated.
- ◇ No radioactive waste will be disposed until a minimum of ten half-lives of the radioisotope has passed since the time of the pick-up. If more than one short half-lived radioisotope is present in the container, ten half-lives of the longest half-lived material shall have passed before any material in that container is disposed.

## 5. Radiation Emergency Procedures

### 5.1 Definition and Purpose

A radiation emergency is any incident resulting from the use of radioactive substance that presents or threatens to present an internal or external radiation hazard to personnel.

The fundamental purposes of the radiation safety program are:

- To prevent internal contamination. This could result from ingestion, absorption, entry through wounds or inhalation of radioactive material.
- To reduce personnel exposure to external radiation as low as reasonably achievable.
- To guard against damage to property or injury to personnel from the use of radioactive materials.

### 5.2 Procedures

In the event of an emergency or suspected emergency, e.g. major spill, overexposure, etc., the RSO, the Area Radiation Safety officer, and the RI shall be notified immediately without such action as to cause excessive spread of contamination. See RCC Form 12 for telephone numbers and additional emergency information.

The RI shall be responsible for the decontamination procedures necessary and shall carry out these procedures under the direction of the RSO or persons designated by him.

5.2.1 Minor spills involving no significant radiation to personnel:

- Notify all other persons in the area at once.
- Permit only minimum number of persons necessary to deal with the spill into the area.
- Confine the spill immediately.



#### Liquid spills:

- Don protective gloves.
- Drop absorbent paper on spills.
- Notify the RSO and RI as soon as possible, giving all details of the spill.
- Survey the area with an appropriate meter or other appropriate technique.
- Check the area around the spill, as well as hands, feet and clothing.
- Put contaminated gloves, absorbent paper, and other clean-up materials into a properly labeled waste container.
- Survey the area with an appropriate meter or other appropriate technique.
  - ◊ Check the area around the spill, as well as hands, feet and clothing.

#### Dry spills:

- Don protective gloves.
- Gently dampen area thoroughly and cover it with absorbent paper taking care not to spread the contamination.
- Notify the RSO and RI as soon as possible, giving all details of the spill.
- Survey the area with an appropriate meter or other appropriate technique.
  - ◊ Check the area around the spill, as well as hands, feet and clothing.

#### 5.2.2 Major spills involving radiation hazard to personnel:

- Notify all persons not involved in the spill to vacate the room at once.
- Make no immediate attempt to clean up the spill.
  - ◊ If spill is liquid and the hands are protected, right the overturned container.
  - ◊ If the spill is on the skin, flush thoroughly with water in the nearest sink. Do not scrub or use strong detergents.
  - ◊ If the spill is on the clothing, discard outer or protective clothing at once.
- If possible, switch off all fans and air conditioners.
- Vacate the room and prohibit unauthorized entrance to contaminated area.
- Notify the RSO and RI at once and give all details of the accident.
- The spread of radioactive contamination can be diminished by restricting the movements of potentially contaminated persons to a local zone just outside of the spill area until the extent of shoe and clothing contamination is ascertained.
- Anyone who might have been contaminated shall be monitored for radioactivity and, if contaminated, shall discard that clothing and be



decontaminated. If no means are available for monitoring, it shall be assumed that the person is contaminated.

- Immediately take necessary steps to decontaminate personnel involved. Under no circumstances shall an untrained person attempt to examine or clean up the radioactive material.
- Decontaminate the area under the supervision of the RSO or his/her designate.
- Monitor all persons involved in the spill and cleaning to determine the effectiveness of decontamination.
- Permit no person to resume work in the area until a survey is made and approval of the RMS office is secured.

5.2.3 Accidents involving radioactive dust, mists, fumes, organic vapors and gases:

- Notify all other persons to vacate the room immediately.
- Hold breath and close escape valves. Switch off air circulation devices if possible and if time permits.
- Vacate the room.
- Notify the RSO and RI at once giving all details.
- Ascertain that all doors giving access to the room are closed and sealed by the use of wide masking tape or adhesive tape and heavy paper. Post conspicuous warning signs or guards to prevent accidental opening of doors.
- Report at once all known or suspected inhalations of radioactive materials.
- Decontaminate the area under the supervision of the RSO or designate.
- Monitor all persons suspected of contamination.

5.2.4 Injuries to personnel involving radiation hazards:

- Wash minor wounds immediately under running water while spreading the edges of the wound.
- Report all radiation accidents (wounds, overexposure, ingestion, inhalation, etc.) to the RSO as soon as possible, Extension 1-6702.
- Permit no person involved in a radiation injury to return to work without the approval of the RSO and the attending physician.
- Have appropriate bioassays performed as specified by the RSO.

5.2.5 Fires involving radioactive material:

- Notify all persons in the room and building at once.
- Notify the fire department and RSO of the emergency involving radioactive material.



- Attempt to put out minor fires if radiation hazard is not immediately present (Refer to the University's online fire extinguisher training).
- Following the emergency, monitor the area and determine the protective devices necessary for safe decontamination.
- Decontaminate under the supervision of the RSO or his/her designate.
- Monitor all persons involved in combating the emergency.
- Permit no person to resume work without approval of the RSO.

## 6. Decontamination Procedures

### 6.1 Personnel Contamination-External

External contamination of personnel can be hazardous in three ways:

- It may cause injury from local exposure of the skin.
- It may penetrate the intact skin (especially in the presence of certain organic solvents).
- It may eventually be transferred into body by ingestion or inhalation.

The danger of the loose activity being eventually carried into the body is by far the most critical hazard, so decontamination procedures are primarily concerned with loose contamination.

- If the contamination is localized; it is often more practical to mask off the affected area and cleanse with swab, before risking the danger of spreading the contaminant by general washing.
- The skin may become sensitive following repeated application of detergents to the same area; therefore, care should be taken to avoid repeated application. In any case, one shall avoid the use of organic solvents that may increase the probability of the radioactive materials penetrating through the pores of the skin.
- After each decontamination operation, the treated area shall be dried with a fresh non-contaminated towel or swab and monitored. All materials used in the decontamination process shall be treated as contaminated material.



6.1.1 The recommended procedures for general washing of contaminated areas, especially hands, are as follows:

- Wash for not less than two minutes, not more than three minutes by the clock with a mild pure soap in tepid water with a good lather, covering the entire affected area thoroughly. Give special attention to areas between fingers and around the fingernails. The outer edges of the hands are readily contaminated and often neglected in the washing.
- Do not use highly alkaline soaps or abrasives. Rinse thoroughly and repeat, as monitoring indicates, until the desired degree of decontamination is achieved, but not to exceed three or four washing/rinses.
- If the above procedure is not sufficient to remove the contamination, scrub the hands with a soft brush using a heavy lather and tepid water. This scrubbing is primarily to agitate the cleaning agent, and hence prolonged scrubbing without changes of reagent is of questionable value. For this reason, at least three washes, including rinses, should be made within eight minutes, of which at least six minutes should be applied to the brush – not sufficient to bend the bristles out of shape or to scratch or erode the skin. Rinse thoroughly and monitor.
- Apply lanolin or hand cream to prevent chapping. In more serious cases of hand contamination, the following steps may be taken. This procedure shall be used only if thorough soap and water scrubbing fails to remove the contamination, and then only under supervision of the RSO.
  - ◇ Wash hands lightly in about 5 per cent solution of sodium hypochlorite.
  - ◇ Rinse thoroughly in tepid water.
  - ◇ Rinse hands lightly with a small amount 3N hydrochloric acid.
  - ◇ Rinse hands thoroughly with tepid water.
  - ◇ Apply hand lotion to prevent dryness and cracking of the skin.
  - ◇ Further attempts to remove contamination should be made only under medical supervision.

## 6.2 Personnel Contamination – Wounds

When the skin is lacerated by glassware, hypodermic needles, or sharp instruments containing radioactive materials, the wounded area shall be washed immediately under a stream of cold water. After first aid measures have been taken, whoever is in charge shall



notify the RSO and otherwise follow the emergency procedures found in Section 7 of these rules.

### **6.3 Personnel Contamination – Internal**

Internal contamination is essentially a medical problem, similar in some ways to the absorption of chemical toxins, special corrective procedures shall therefore be carried out only under medical advice and supervision.

The aims of the corrective procedures are:

- 6.3.1 Try to eliminate as much of the internally introduced contaminant still remaining in the mouth, gastrointestinal or respiratory tract, as quickly as possible and try to prevent or reduce its uptake into the bloodstream and tissues.
- 6.3.2 Try to prevent the fixation of the contaminant in the body or try to increase its excretion from the body.
- 6.3.3 For the first of these aims it is necessary that the contaminated person or another non-medical person take immediate action, for instance, to promote the mechanical elimination of the contaminant by vomiting or expectoration. For the second of these aims more is complicated, chemical or physicochemical methods are required. Hence, treatment is a medical matter and shall be undertaken as soon as possible but only under medical supervision.
- 6.3.4 In all cases of internal contamination, the RSO shall be notified as soon as possible and the emergency procedures listed in Section 5 followed.

### **6.4 Non-Human Contamination**

- 6.4.1 The exact procedures for facility decontamination depend on the type of equipment and facility contaminated, the chemical and physical form of the specific isotope involved, and the extent of the area contaminated.
- 6.4.2 The material used in the decontamination procedures should be considered contaminated and disposed of as radioactive waste.
- 6.4.3 The possibility of disposal of contaminated objects shall be considered.
- 6.4.4 It is sometimes more economical (in terms of time and risk to personnel) to dispose of a piece of equipment than to decontaminate it.



Each researcher shall insure that his personnel are familiar with the following:

- The technique of “concentrate and confine” shall be used to avoid the spread of the contamination.
- Decontamination shall be carried out as soon as possible.
- The decontamination procedures should avoid large amounts of liquid. The working materials should be moist but not so moist that they will flow.
- If an excess of liquid contaminant is present, blotting should be the first step in the decontamination procedure.
- In proceeding with decontamination, the least caustic and least abrasive procedures should be tried first.
- Any procedures that produce dust or other air-borne contaminants shall be avoided.
- With short half-life radioisotopes, decay is an acceptable method of decontamination, provided that during decay some provision is made for preventing the spread of contamination and exposure of personnel.
- Decontamination of movable items should be done in a hood.
- In general, glass may be cleaned with chromic acid. In general, decontamination of a rough surface will require the use of brush (e.g. a small soft brush or toothbrush). Masking tape should be used to pick up dry powder contaminants.
- Aerosols and chemicals that would produce gases should be avoided. Sometimes a non-radioactive carrier is useful.
- Soft beta and alpha radiation emitters which cannot be removed may be sealed in by painting, with approval of the RSO. This technique is normally limited to areas not subject to abrasion. Disposable plastic gloves shall be worn throughout the decontamination procedure.

After each step of the decontamination procedure the contaminated item should be dried and monitored. It should be remembered that moisture can reduce the actual level of the radiation considerably (in the case of alpha or beta emitters) and give a false impression that the decontamination has been successful.

## **6.5 Incidents involving sealed sources**

For an emergency situation that may occur concerning a sealed source that has been exposed unintentionally, is unshielded or compromised, the following safety instructions should be considered:

- Immediately secure and post the restricted area, and maintain continuous





surveillance and restrict access to the restricted area.

- Notify the RSO immediately.
- Retrieval operations should be supervised by the RSO.
- No source or suspected source should be handled directly with bare hands.
- Determine if additional dosimetry will be required during source retrieval.
- Appropriated survey instruments shall be used for the response activity.
- Expedient methods of reducing unintended exposure to staff and the public, such as shot bags, sandbags, steel plates, and remote handling devices.
- The RSO shall make required notifications to the NRC.

## **7. Personnel Training Program**

### **7.1. Training for Individuals Working With Radioactive Materials**

7.1.1. A Radiation Safety Training course is offered on-line to users of sealed and non-sealed radioactive materials. The Radiation Safety Officer will develop the course. This training will be completed, and the exam taken and passed, prior to beginning any work with radioactive materials. Topics covered are listed below.

- Basic Fundamentals of Radiation
- Atomic Structure and Particles
- Radioactivity and Types of Radiation
- Interaction With Matter
- Radioactive Decay
- Units of Radiation Measurements, Biological Effects of Radiation and Radiation Exposure Limit
- Principles of Radiation Film Badges and Detection Instruments
- Basic Principles of Radiation Protection
- Reducing External Radiation Exposure
- Reducing Internal Radiation Exposure
- Personnel Protecting Rules
- Laboratory Facilities (including survey techniques and frequency)
- Emergency Procedures
- Decontamination Procedures
- Prenatal Radiation Safety

7.1.2 Either On-Line or Take Home Exam – Passing score 80% is the standard. Individuals not passing will receive additional instruction from the Radiation Safety Officer or the Radiation Safety Specialist, in areas determined deficient.



- 7.1.3 Users requiring specific training, including, but not limited to, waste preparation, lab surveys for contamination, package receipt, and use of a survey meter, will receive in-person instruction by the Radiation Safety Officer or the Safety Specialist.
- 7.1.4 Records documenting the training of each individual will be maintained in the Risk Management and Safety Department. In addition to the above training, personnel shall be provided verbally and/or in writing the following information.
- All researchers, responsible investigators, etc., who use radioactive material.
    - ◇ Have available to them a copy of the Radiation Safety Procedures to be employed.
    - ◇ Have available to them a copy of the Radiation Safety Procedures to be employed.
    - ◇ Be informed of the following:
      - The NRC byproduct material license and its conditions and provisions may be found in the Risk Management and Safety Office, Room 636 Grace Hall. It is available for examination Monday through Friday from 8 a.m. to 5 p.m.
      - Parts 19 and 20 of Title 10 Code of Federal Regulations are also available for examination during the hours listed above.
      - Notice of violations, proposed civil penalty or order and any response from the licensee are also available for examination in the Risk Management and Safety Office during the hours listed above.
      - It is the obligation of the employee to report any unsafe or potentially unsafe conditions that may exist within a restricted area. Should such a situation be observed, immediately notify the Area Radiation Safety Officer, and the Radiation Safety Officer.
- 7.1.5 Female employees occupationally exposed to ionizing radiation will be informed verbally and in writing of the possible health risks to children of women who are exposed to radiation during pregnancy. The text for instruction will be the Regulatory Guide 8.13. Further consultation with a representative of Risk Management and Safety will occur if written notification of pregnancy is received by that office.



## 7.2 Training for Individuals Frequenting Restricted Areas

University personnel whose work or study requires them to enter a restricted area more than two times a week, but who do not conduct work with radioactive materials, shall be considered to frequent a restricted area. A training program in radiation safety will be required, on an annual basis, of those individuals frequenting a restricted area. The training will cover the meanings of various radiation signs, labels, and symbols, dose limits, prohibition of food and drink in restricted areas, and emergency contacts if exposure, ingestion, or contamination is suspected. The Risk Management and Safety office will maintain a training record of each individual who attends a training program. This program will be conducted either in person by the RSO or his designee, or be a web based program developed by the RSO.

## 7.3 Retraining for Individuals Working with Radioactive Materials

A retraining program will be required, on an annual basis, of individuals working with radioactive materials. These individuals will receive approximately 45 minutes of retraining, at least twenty minutes of which will cover emergency procedures. This program may be conducted in either a classroom environment, or on the www. The Risk Management and Safety office will maintain a training record on each individual who completes a retraining program.

## 7.4. Retraining for Individuals Frequenting a Restricted Area

A retraining program is required, on an annual basis, of individuals frequenting a restricted area. These individuals will receive approximately, 30 minutes of retraining, at least fifteen minutes of which will cover emergency procedures. Requirements of training records are the same as in Sections 7.2 and 7.3 above.

## 75 Training for Users of Machine Produced Radiation

7.5.1 A Radiation Safety Training course is offered on-line to users of machine produced radiation. The Radiation Safety Officer will develop the course. This training will be completed, and the exam taken and passed, prior to beginning any work with radioactive materials. Topics covered are listed below.

- Principles of Radiation Protection as referenced in Section 7.1.2 of this procedure.
- Prenatal Radiation Safety
- Emergency Procedures



## 8. Machine Produced Radiation

- 81 All machines producing ionizing radiation shall be registered with RMS.
- 82 All machines producing ionizing radiation shall be surveyed in accordance with standards of 410 IAC 5, the Indiana Rule for Radiation Control, at frequencies specified in the Rule.
- 83 Survey forms for each type of machine are as follows:
  - 8.3.1 Human use machines – Appendix A
  - 8.3.2 X-ray diffractometers – Appendix B
  - 8.3.3 Particle accelerators
    - Physics Department – Appendix C
    - Radiation Laboratory, Van de Graaf 1 - Appendix D
    - Radiation Laboratory, Van de Graaf 2 – Appendix E
    - Radiation Laboratory, Linac – Appendix F

## 9. Enforcement Actions

The RCC has the delegated authority to approve the use of radioactive materials under the terms of License Number 13-01983-15 issued to the University by the Nuclear Regulatory Commission (NRC), and radiation emitting machines under terms of Registration Numbers 30016, 30035, and 30046 issued by the Indiana State Department of Health (ISDH.) Retention of approval to use radioactive materials and radiation emitting devices by an individual is contingent upon adherence to applicable NRC and ISDH policies. The following guidelines will be followed when an approved user violates regulations of conditions of use.

### 9.1 Major Violations

- 9.1.1 More than three minor violations in any twelve-month period.
- 9.1.2 Transfer of radioactive materials or radiation emitting devices to an unapproved facility or individual.
- 9.1.3 Not securing radioactive material and/or the laboratory to prevent unauthorized access.

### 9.2 Enforcement Actions for Major Violations

- 9.2.1 First Violation: Retraining for all involved, and written response from the RI describing actions to prevent re-occurrence. Letter to the Department Chair describing the violation and the corrective actions to be taken.
- 9.2.2 Second Violation (within a one year period): Ninety-day suspension of approval to use radioactive materials and/or radiation producing machines. RI shall reapply to RCC for approval if wishing to resume use after ninety days.
- 9.2.3 Third Violation (within a one year period): Permanent suspension of approval to use radioactive materials and/or machines.



### **93 Minor Violations**

- 9.3.1 Not identifying new personnel and making them available for training.
- 9.3.2 Failure to report known or suspected contamination, leaks, or spills.
- 9.3.3 Not wearing appropriate personal protective equipment such as:
  - Safety eyewear
  - Disposable gloves
  - Laboratory coat
- 9.3.4 Not wearing appropriate badges (film, ring, etc.)
- 9.3.5 Failure to submit to applicable bioassays.
- 9.3.6 Not informing Radiation Safety personnel of survey meters requiring calibration.
- 9.3.7 Failure to perform required laboratory surveys.
- 9.3.8 Failure to post required warning signs or labels, or failure to label items such as radioactive waste.
- 9.3.9 Consuming or storing food and/or beverages in the laboratory.

### **94 Enforcement Actions for Minor Violations**

- 9.4.1 First Violation: Written warning to RI, copied to Department Chair and ARSO
- 9.4.2 Second Violation: Additional training and written response from RI describing corrective measures.
- 9.4.3 Third violation: Repeat the Enforcement Actions for the First and Second Violations. A follow-up unannounced inspection will be conducted by RMS Personnel within thirty days of the finding of the violation. If the previous violation still exists or a new minor violation is found at the time of that inspection, a First Major Violation will result.

NOTE: These examples of violations are not all-inclusive, and the severity level of each violation may be subject to review by the RCC.



## **9.5 Implementation of Enforcement Actions**

The RSO and the Chair of the RCC will make a preliminary determination of the Severity Level. A meeting of the RSO, Radiation Safety Specialist, and ARSO will be held as soon as practical to review major and third minor violations. Those individuals will determine, and recommend to the RCC, enforcement actions that are appropriate for the nature and circumstances of the violation. The Chairman of the RCC will notify RCC members of the enforcement actions. The Radiation Safety Specialist will ensure that enforcement actions are implemented at the local level. The RCC will review the enforcement actions at the next scheduled meeting to ratify or modify the actions as the final authority.

## **9.6 Reinstatement and Appeals**

An individual whose permit has been suspended shall apply to the RSO for reinstatement of approval to use radioactive materials or radiation emitting devices after the conditions of the enforcement actions are satisfied. The RCC will review the request to determine if the conditions of the enforcement actions have been adequately satisfied.

The Chair of the RCC may reinstate the permit after consultation with the RSO. An individual may appeal recommendations of the RSO and actions of the Chair and the RCC, and has the right to be present at the deliberations on the case.

RCC Form 1  
 University of Notre Dame  
 APPLICATION FOR APPROVAL AS A RESPONSIBLE INVESTIGATOR  
 IN THE USE OF RADIOACTIVE MATERIALS AND RADIATION SOURCES

Name: \_\_\_\_\_ Department: \_\_\_\_\_

Office: \_\_\_\_\_ Lab: \_\_\_\_\_

Phone: \_\_\_\_\_

Type of training:

Type	Where	Duration of Training	Formal		On The Job	
			Yes	No	Yes	No
Principles and Practices of Radiation Protection			Yes	No	Yes	No
Radioactive Measurement, Monitoring Techniques, and Instruments			Yes	No	Yes	No
Mathematics and Calculations Basic to the Use and Measurement of Radioactivity			Yes	No	Yes	No
Biological Effects of Radiation			Yes	No	Yes	No

Formal Courses: (List all courses pertaining to radioisotopes, atomic and nuclear structure, radiochemistry, radiobiology, etc.)

Title of Course	Where Trained	Duration
(a)		
(b)		
(c)		
(d)		

**RCC Form 1**
**Experience:** (Actual use of radionuclides or radiation producing machines)

<b>Radionuclide</b>	<b>Maximum Amount (mCi)</b>	<b>Where Experience Gained</b>	<b>Duration</b>

**Type of use:**

**Statement of Intended Application(s) of Radioactive Material or Radiation Sources**

<b>Radionuclide</b>	<b>Maximum Quantities on Hand at One Time</b>	<b>Location of Use: Building &amp; Room</b>

Intended use of each radionuclide. Give full explanation of use(s).





RCC Form 1

STATEMENT OF AGREEMENT:

The below named individual signifies that he/she has read and is willing to abide by the University of Notre Dame regulations governing the use of radioisotopes and other sources of ionizing radiation. The undersigned agrees to comply strictly with all such rules and regulations and hereby waives any right or recourse against the University of Notre Dame for any damage whatsoever resulting from any failure to conform with said regulations. He/She further assumes responsibility for ascertaining that employees, students and associates working under his/her direction shall comply with the regulations of the University of Notre Dame governing the use of radioactive materials and radiation sources.

I have read Section 4.4.1 of the Radiation Safety Manual regarding the storage and use of food, beverage, and tobacco and application of cosmetics in radioisotope laboratories. I understand the serious consequences that may arise if practices of this nature occur.

Date \_\_\_\_\_

Signature \_\_\_\_\_

Approval shall be for a period of no more than one year. The expiration date shall be April 30<sup>th</sup> of every year.

Approximately 30 days prior to expiration, current Responsible Investigators shall receive a renewal application from the Radiation Safety Officer.



RCC Form 2  
University of Notre Dame  
APPLICATION FOR CONTINUED USE OF RADIOACTIVE MATERIAL

Your authorization as a Responsible Investigator to possess and use radioactive material expires April 30<sup>th</sup> of every year.

Do you wish to renew your authorization to possess and use radioactive material?

Yes \_\_\_\_\_ No \_\_\_\_\_

You are now approved to possess and use the following radionuclides and quantities:

Radionuclides:

Quantities:

_____	_____
_____	_____
_____	_____
_____	_____

I would like to remove the following radionuclides from my list of approved radionuclides listed above:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

I would like approval to increase the quantity of a radionuclide or radionuclides listed above and/or to possess new radionuclides not previously authorized.

Radionuclide(s)    Increased Quantity  
Max Quantity

New Radionuclide(s)

_____	_____	_____	_____
_____	_____	_____	_____

Explain fully the reason for an increase in quantity for each radionuclide and the use of each new radionuclide. (Use reverse if necessary)

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Briefly state below significant changes that are anticipated in the use of radioactive material and/or the use of laboratory facilities. (Use reverse if necessary)

Approved Facilities: \_\_\_\_\_

Room(s): \_\_\_\_\_

Building(s): \_\_\_\_\_

The undersigned agrees to comply with all University and Nuclear Regulatory Commission Regulations and assumes responsibilities for ascertaining that employees, students, and associates working under his/her direction shall comply with these regulations.

Signed \_\_\_\_\_

Date \_\_\_\_\_



RCC Form 3
University of Notre Dame
APPLICATION FOR RADIOISOTOPES OR ADDITIONAL QUANTITIES

Name: Department: Office Room Number:
Lab Room Number: Telephone:

Check below as appropriate:

- This is an application to possess new isotopes not previously authorized.
This is an application to possess additional quantities of isotopes exceeding my authorized possession limit.
Current Possession Limit (uCi) (mCi)(Ci) Radionuclide

Table with 3 columns: Isotope(s), Maximum quantities on hand at one time (Building and Room), Location of Use

Explain fully below the use of each radioisotope (use reverse side if needed).

Date Signed

Temporary Approval Date:

Temporary Authorization No:

Approved Radiation Control Committee:

Date:

Authorization Number:



RCC Form 4
University of Notre Dame
FACILITY APPROVAL FOR RADIONUCLIDE USAGE

Department: \_\_\_\_\_ Building and Room: \_\_\_\_\_

Responsible Investigator: \_\_\_\_\_ Date Submitted: \_\_\_\_\_

Table with 3 rows: Byproduct Material to be Used, Chemical or Physical Form, Maximum Possession Quantity. Each row has 8 empty columns.

Sketch of Facility:

Large empty rectangular box for sketching the facility.

Type of Floor Covering \_\_\_\_\_ Bench Top Materials \_\_\_\_\_ Walls & Ceilings \_\_\_\_\_
Hood(s) Singly Ducted Yes \_\_\_\_\_ No \_\_\_\_\_
Flow Rate With Sash Openings FPM \_\_\_\_\_ FPM \_\_\_\_\_ FPM \_\_\_\_\_
Number of Persons Normally Working Area: \_\_\_\_\_
Number of Individuals in the Following Educational Categories:
Undergrad \_\_\_\_\_ Grad \_\_\_\_\_ Technician \_\_\_\_\_ Postdoc or Faculty \_\_\_\_\_

Are other personnel working in this facility approved radioisotope workers?

Horizontal line for answer.

Is this area also used as a study/office area for research personnel?

Horizontal line for answer.

List monitoring devices located in this facility: (Make, Model, Type, Range)

Horizontal line for answer.

List special handling facilities: (Shielding, Glove boxes etc.)

Horizontal line for answer.

Approved: (Radiation Safety Officer) \_\_\_\_\_ Date: \_\_\_\_\_

Approved: (Radiation Control Committee) \_\_\_\_\_ Date: \_\_\_\_\_



RCC Form 5  
University of Notre Dame  
**RADIOISOTOPE PACKAGE EXAMINATION**

RADIOACTIVE MATERIAL  SHIPPING PAPER	CARRIER NAME Risk Management and Safety University of Notre Dame	REQUISITION #	Req. Date	P.O. Number #
Emergency Phone Number 574-631-5555	Shipper's Radioactive Material License 13-01983-15	Date & Time Received		Time of Survey
CONSIGNEE - Responsible Investigator			CONSIGNEE - Address	
"This package conforms to the conditions and limitations specified in 49CFR 173.421 for radioactive material, excepted package-limited quantity of material. UN2910."			Radioactive Material Type A package non-special form, non-fissile material, or fissile excepted. UN2915.	
DOT LABEL "RADIOACTIVE"	TRANSPORT INDEX	PHYSICAL & CHEMICAL FORM	INDIVIDUAL RADIONUCLIDES	TOTAL PACKAGE ACTIVITY MBq                      mCi

Maximum Radiation Levels:				
	mRem/hr		mSv/hr	
	Beta-gamma	Alpha	Beta-gamma	Alpha
Package Surface	_____	_____	_____	_____
Package 1 Meter	_____	_____	_____	_____
Isotope Shielded	_____	_____	_____	_____
	_____	_____	_____	_____
Isotope Unshielded	_____	_____	_____	_____
Maximum Contamination Levels:				
	DPM/100 cm <sup>2</sup>		MBq/100 cm <sup>2</sup>	
Location	Beta-gamma	Alpha	Beta-gamma	Alpha
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

Package Checked by: \_\_\_\_\_ Date: \_\_\_\_\_

Package Received by: \_\_\_\_\_ Date: \_\_\_\_\_

EMERGENCY RESPONSE REFERENCE ERG # 163



RCC Form 6
University of Notre Dame
REQUEST FOR FILM BADGE SERVICE

Instructions: Prepare two copies. Submit original to Risk Management and Safety office. One copy is for your files. If you have had previous occupational exposure at another facility, please complete and sign the form. Authorization for Releasing Radiation Exposure Information, so that we may maintain your complete exposure history as required under Federal Regulations.

Send completed form to: RADIATION SAFETY OFFICER, 636 GRACE HALL

Please type or print clearly \_\_\_\_\_ New Order ( ) Change in Service ( )
Name of person requesting service: \_\_\_\_\_
Department: \_\_\_\_\_ Building: \_\_\_\_\_ Room: \_\_\_\_\_
Birth Date: \_\_\_\_\_ Gender: M ( ) F ( )
Type of Exposure (nuclide used or energy of radiation): \_\_\_\_\_
Remarks: \_\_\_\_\_
Approved by: \_\_\_\_\_ Date: \_\_\_\_\_
(Responsible Investigator)

.....IMPORTANT.....PLEASE NOTE.....

Assignment of Exposure: A film badge may be used only by the person to whom it is assigned. Exposures will be charged to the individual whose name appears on the film pack.

Film Badge Changes: All film badges will be changed on approximately the first day of every other month. Film badges will normally be distributed by a designated person in each department. The user shall return his or her expired badge promptly to this designated person.

Cost for Service: Direct charges for film badge service will be made against specific account. It is therefore, important to stress economy in the overall interest of your group or department. To avoid unnecessary expense, the user is responsible for notifying the Risk Management and Safety office or the department's designated film badge distributor when he or she terminates work with radiation or radioactive materials.

.....DO NOT WRITE IN THIS SPACE.....

Date Started: \_\_\_\_\_ Assigned Badge Number \_\_\_\_\_
Dated Stopped: \_\_\_\_\_ Type of Badge: \_\_\_\_\_
Approved by: \_\_\_\_\_



RCC Form 7  
University of Notre Dame  
AUTHORIZATION FOR RELEASING RADIATION EXPOSURE

TO: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

ATTENTION: \_\_\_\_\_

You are hereby authorized to furnish to the Radiation Safety Officer, University of Notre Dame, any or all information concerning my radiation exposure history as developed while I was employed or assigned at \_\_\_\_\_ during the period from \_\_\_\_\_ to \_\_\_\_\_. You are further authorized to include in your transmittal to said person any or all information concerning my radiation exposure history acquired by you from other persons, employers or agencies if such records are in your possession.

Please transmit my radiation exposure record to:

RADIATION SAFETY OFFICER  
Risk Management & Safety  
636 Grace Hall  
University of Notre Dame  
Notre Dame, Indiana 46556

Signature \_\_\_\_\_

Date \_\_\_\_\_



RCC Form 8  
University of Notre Dame  
PRENATAL RADIATION EXPOSURE  
TRAINING RECORD

(Please Print)

NAME: \_\_\_\_\_

DEPARTMENT: \_\_\_\_\_

PRINCIPAL INVESTIGATOR LAB/ROOM: \_\_\_\_\_

I certify by my signature below that I have received instruction on the health risks and protection measures related to prenatal radiation exposure, as described in the U.S. Nuclear Regulatory Guide 8.13.

I understand that during the entire gestation period, the dose to the fetus from occupational radiation exposure of the expectant mother should not exceed 0.5 rem, and that vigorous efforts shall be made to keep radiation exposure of an embryo or fetus to the very lowest practicable level.

I fully understand that in the event of my pregnancy, to ensure that positive measures will be taken to maintain my occupational radiation exposure as low as reasonably achievable, that it is in my best interest to declare my pregnancy in writing to my supervisor and the Radiation Safety Officer as soon as possible.

Signature \_\_\_\_\_

Date \_\_\_\_\_

FILE WITH INDIVIDUAL'S  
RADIATION EXPOSURE RECORD





RCC Form 9  
University of Notre Dame  
RADIATION USER INSPECTION REPORT

Responsible Investigator: \_\_\_\_\_ Date of Inspection: \_\_\_\_\_  
 Person Conducting Survey: \_\_\_\_\_ Laboratory Location: \_\_\_\_\_

Radionuclides & Amounts Used Since Last Survey

Radionuclide	Amount (uCi)	Radionuclide	Amount (uCi)
	Amount (uCi)		

Survey Meter Results

Area	mR/hr	Bkg	Net
Counter Make:		Model:	

Wipe Test Results

Area	dpm	Bkg	Net
Counter Make:		Model:	

**Contamination Levels**

Survey Meter - Radiation levels exceeding 2 times Background/Wipe Test - 20 dpm above background for 125I, 200 dpm above background for 90Sr, 1000 dpm above background for all others.

If contamination is found, decontaminate the area as described in Part X, Decontamination Procedures; Section 8.4, Non-Human Contamination and then resurvey area. Continue decontamination procedures until radiation levels are below contamination levels. Call Risk Management & Safety office (1-5037) for assistance if necessary. **Wipe test results shall be attached to this Inspection Report Form.**

**Radiation Level Limits for Radiation Sources**

The dose rate at the surface of any stored radioactive material, such as stock solutions or waste, shall not exceed 5.0 mR/hr. If exceeded appropriate shielding shall be used to reduce radiation levels below 5.0 mR/hr.

**Waste Containers**

Checked for leakage

Leakage not found: \_\_\_\_\_

Leakage found: \_\_\_\_\_ RMS notified: \_\_\_\_\_ (Date and time): \_\_\_\_\_



RCC Form 10  
 University of Notre Dame  
 RISK MANAGEMENT AND SAFETY RADIOISOTOPE LAB AUDIT

Responsible Investigator: \_\_\_\_\_  
 Laboratory Building: \_\_\_\_\_ Room(s): \_\_\_\_\_  
 Date: \_\_\_\_\_ Time: \_\_\_\_\_

Radioisotope User	RAM Used	Badge Required	Worn	Last Training

Radioisotope in Labs (mCi)	Approved Limit (mCi)	Current Inventory

Is there a copy of the Radiation Safety Manual in Lab? \_\_\_\_\_ Do personnel know where to find it? \_\_\_\_\_

Are personnel aware of the telephone number to call if a spill occurs after-hours? \_\_\_\_\_

Radioisotope log book in lab? \_\_\_\_\_ Is it up to date? \_\_\_\_\_

Contamination surveys conducted and recorded at proper intervals? \_\_\_\_\_

Survey meter required? \_\_\_\_\_

Make \_\_\_\_\_ Model \_\_\_\_\_ Battery check \_\_\_\_\_

Last calibrated \_\_\_\_\_ Checking source reading \_\_\_\_\_

Are lab personnel aware of check source location and purpose? \_\_\_\_\_

Leakage noted: Waste containers \_\_\_\_\_ Storage area \_\_\_\_\_

Evidence of smoking, eating, drinking, gum chewing or cosmetic application in lab? \_\_\_\_\_



RCC FORM 10

Posting: Radioactive Materials \_\_\_\_\_ Radiation Producing Machines \_\_\_\_\_

No Eating, Drinking, Smoking \_\_\_\_\_

Proper Lab Attire: Lab coats \_\_\_\_\_ Gloves \_\_\_\_\_ Goggles \_\_\_\_\_

Appropriate shielding in lab: \_\_\_\_\_

Security: Was door locked if no one was present of challenged entrance? \_\_\_\_\_

Radioisotopes left in non-secured areas? \_\_\_\_\_

Fume Hoods:

Room No.	FPM	Hood No.

Wipe test and survey meter results on following page(s).

Comments, observations, and recommendations:


Signature of person conducting audit \_\_\_\_\_

Date of audit \_\_\_\_\_

Next recommended audit date \_\_\_\_\_



RCC Form 11  
 University of Notre Dame  
 REPORTING FORM FOR RADIOACTIVITY  
 IN AIR CONCENTRATIONS TO UNRESTRICTED AREAS

Responsible Investigator: \_\_\_\_\_ Date of Release: \_\_\_\_\_  
 Department: \_\_\_\_\_ Hood Location: \_\_\_\_\_  
 Radioactive Material: \_\_\_\_\_ Chemical Form/Reaction: \_\_\_\_\_  
 Approx. Quantity Used in Experiment: \_\_\_\_\_  
 Approx. Quantity Released During Experiment (1.): \_\_\_\_\_

Length of Release Time \_\_\_\_\_ minutes

Number of Hours Per Day Hood is in Operation \_\_\_\_\_

Area of Exhaust Opening \_\_\_\_\_ ft<sup>2</sup>

Air Flow Across Face of Opening \_\_\_\_\_ linear ft/min

Volume of Air Emitted/min \_\_\_\_\_ ft<sup>3</sup> x 2.83x10<sup>4</sup> ml/ft<sup>3</sup> = \_\_\_\_\_ ml

Volume of Air Emitted/week (x10080) \_\_\_\_\_ ml

Volume of Air Emitted/year (x5.2x10<sup>5</sup>) (2.) \_\_\_\_\_ ml

Concentration of \_\_\_\_\_ released in air averaged over a one year period.

$$\begin{array}{l} \text{(1.)} \quad \frac{\text{uCi}}{\text{ml}} \\ \text{(2.)} \quad \frac{\text{ml}}{\text{ml}} \end{array} = \text{(3.)} \frac{\text{uCi}}{\text{ml}}$$

Maximum Permissible Concentration (MPC) of \_\_\_\_\_ in Air Above Natural Background from 10 CFR 20, Appendix B, Table II, column 1.

(4.) \_\_\_\_\_ uCi/ml

Percentage of MPC Released:

(3.) \_\_\_\_\_ X 100 = \_\_\_\_\_ %



RCC Form 12  
University of Notre Dame  
EMERGENCY INFORMATION  
Campus Security Emergency Number

EMERGENCY # 9 1 1 (From a Campus Phone only, cell phones call 574-631-5555)  
(Fire, explosion, personal injury, etc.)

1. **Security Dispatch 1-5555** (after hours spill, non-injury accidents)

(This number is open 24 hours and should be called to arrange for an ambulance.)

2. **Risk Management and Safety Department**

**8:00 am to 5:00 pm**

Radiation Safety Officer – Andrew Welding 574-631-6702

3. **Radiation Control Committee**

Chairman - Dr. Peter Burns 574-631-7852

After Hours 574-258-9034

4. **Notre Dame Fire Department**

574-631-6200

5. **Memorial Hospital**

574-284-6800

Memorial Hospital of South Bend is the designated Treatment center for radiation ingestion or injury due to the "Poison Control Center" facilities located there and the existence of radioisotope treatment program at the hospital.

6. **University Health Services**

Days: 574-631-7567 Nights: 574-631-7154

7. **Notre Dame Wellness Center**

574-634-9355

**Hours**

Monday – Friday: 7:00 a.m. - 7:00 p.m.

Saturday: 8:00 a.m. - 12:00 p.m.

Football weekends: Saturday closed, Sunday 1:00 p.m. - 5:00 p.m.



APPENDIX A

University of Notre Dame

STATIONARY RADIOGRAPHIC MACHINE AND EXTRAORAL DENTAL MACHINE INSPECTION

Facility Registration Number		Name of Facility	
Date of Inspection (month, day, year)	Date of Last Inspection (month, day, year)	Machine Identification (check one) <input type="checkbox"/> Certified <input type="checkbox"/> Non-Certified <input type="checkbox"/> Mixed	
Check to Add this Machine <input type="checkbox"/>	Check to Delete this Machine <input type="checkbox"/>	Name of New Owner (if applicable)	
Machine Number	Machine Design (use codes)	Location Within Facility	Manufacturer
Model Number	Serial Number	Means of Beam Collimation (check one) <input type="checkbox"/> Adjustable <input type="checkbox"/> Cone <input type="checkbox"/> Diaphragm <input type="checkbox"/> Other <input type="checkbox"/> None	
Maximum Machine rating (kVp)	Maximum Machine Rating (mA/mAs)	Utilization Mode <input type="checkbox"/> F <input type="checkbox"/> M <input type="checkbox"/> P	
Date of Manufacture (month, year)	Date of Installation (month, year)	Exposure switch arrangement in shielded area? <input type="checkbox"/> Yes <input type="checkbox"/> No	

Explain All Unsatisfactory or Not Applicable Answers on SF 47602, Comment Page	Satisfactory	Unsatisfactory	Not Applicable
Exposure at operator's position	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technique chart	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Warning label	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Technique factors indicated before exposure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Indication of x-ray production - visual at operator position	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Indication of x-ray termination - audible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exposure terminated at preset time, mAs, exposure, pulses	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exposure at zero time	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Exposure when "off"	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tube housing assembly stable during exposure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Light illuminance intensity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Phototime mode provided	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Phototime mode indicated on control panel when selected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Multiple tube indication at control panel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Multiple tube indication at tube housing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reproducibility - exposure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reproducibility - timer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Half-value layer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
% misalignment of light vs. radiation field	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
% misalignment of indicated vs. actual field size	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
X-ray field/image receptor centers alignment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Terminate exposures greater than 1/2 second at any time	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Indication of beam axis perpendicular to image receptor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Measure SID within 2% of indicated SID	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>FOR CERTIFIED UNITS ONLY</b>			
PBL available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PBL operational	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
% misalignment of x-ray field vs. image receptor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Timer resets to "zero" or initial setting at end of exposure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Linearity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Signature of Physicist/Inspector	Date (month, day, year)
Printed Name of Physicist/Inspector	Physicist/Inspector Number



APPENDIX B
University of Notre Dame
X-RAY DIFFRACTOMETER SURVEY REPORT

Date of Survey: \_\_\_\_\_ Room Number: \_\_\_\_\_
Manufacturer: \_\_\_\_\_ Building: \_\_\_\_\_
Model Number: \_\_\_\_\_ Department: \_\_\_\_\_
Responsible Investigator: \_\_\_\_\_
Operator(s): \_\_\_\_\_

Equipment Requirements

- a) Safety Devices - prevents entry of body into beam path
Yes \_\_\_\_\_ No \_\_\_\_\_
b) Warning Devices
X-ray tube status (On-Off) \_\_\_\_\_ Failsafe \_\_\_\_\_
Shutter status (On-Off) \_\_\_\_\_ Failsafe \_\_\_\_\_
c) Ports - Are unused ports on housing secured in a closed position?
Yes \_\_\_\_\_ No \_\_\_\_\_
d) Labeling
"Caution - High Intensity X-ray Beam" on source housing \_\_\_\_\_
"Caution Radiation - This Equipment Produces Radiation When Energized" near any switch \_\_\_\_\_
e) Shutters - each port must have a shutter which cannot be opened unless a collimator or coupling has been connected to the port. In effect after regulation is passed?
Yes \_\_\_\_\_ No \_\_\_\_\_
f) Warning Lights "X-Ray ON" Failsafe? Yes \_\_\_\_\_ No \_\_\_\_\_

Radiation Source Housing

With all shutters closed @ 5cm. does not exceed 2.5 mrem/hr. Reading \_\_\_\_\_

Generator Cabinet

Leakage limit @ 5cm. 0.25 mrem/hr. Reading \_\_\_\_\_

Posting on Doors "Caution - X-RAY Equipment"

Person making survey \_\_\_\_\_

Directors Used for survey \_\_\_\_\_

Calibration: \_\_\_\_\_

Observations or comments \_\_\_\_\_



APPENDIX C

Physics Department, University of Notre Dame  
ACCELERATOR INSPECTION DATA SHEET

Date: \_\_\_\_\_

1. GENERAL

Facility: \_\_\_\_\_ Location: \_\_\_\_\_  
Manufacturer: \_\_\_\_\_  
Maximum Operating Voltage: \_\_\_\_\_ Beam Current: \_\_\_\_\_

2. CONTROL PANEL DEVICES

Voltage: \_\_\_\_\_ Current: \_\_\_\_\_  
Timer: \_\_\_\_\_ Interlock Status: \_\_\_\_\_

3. DOSIMETRY (list number of each)

Self-Reading Pocket Dosimeters: \_\_\_\_\_ Last Calibration: \_\_\_\_\_  
Portable Survey Meters: \_\_\_\_\_ Models: \_\_\_\_\_ Last Calibration: \_\_\_\_\_

Area Neutron and Gamma Monitors: \_\_\_\_\_  
Last Calibration: \_\_\_\_\_

Portable Neutron Monitor: \_\_\_\_\_ Last Calibration: \_\_\_\_\_

4. ALARMS AND INTERLOCKS

- a. Operable alarms prior to radiation production: Audible \_\_\_\_\_ Visible \_\_\_\_\_
- b. Operable alarms during radiation production: Audible \_\_\_\_\_ Visible \_\_\_\_\_
- c. Indicate number of: door interlocks \_\_\_\_\_ emergency power off \_\_\_\_\_  
Switches "scram"
  - i. Do all these interlocks function? Yes \_\_\_\_\_ No \_\_\_\_\_
  - ii. Do all these interlocks have a manual reset? Yes \_\_\_\_\_ No \_\_\_\_\_
- d. Are the alarms/interlocks have a manual reset? Yes \_\_\_\_\_ No \_\_\_\_\_
  - i. Are the checkout procedures adequate? Yes \_\_\_\_\_ No \_\_\_\_\_
- e. List location and alarm points of all in-place radiation monitors:

<u>Location</u>	<u>Type</u>	<u>High Alarm</u>	<u>Low Alarm</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____





APPENDIX D
University of Notre Dame
SEMIANNUAL REPORT FOR VAN DE GRAAF NO. 1

Performed by: \_\_\_\_\_ Date: \_\_\_\_\_

Refer to Figure 1 (Van de Graaff No. 1 Facility Layout), Chapter 3, Radiation Operations and Safety Manual, for location of items covered in this report.

1. Operational Check:

The following components of the interlock system, when disengaged, stop the drive motor and prevent it from being started (Drive motor light on operator's console turns off):

- Interlocked Door A ..... ( ) Yes ( ) No
Emergency Stop ..... ( ) Yes ( ) No
Enabling Switch ..... ( ) Yes ( ) No

The following devices give aural or visual indications of drive motor status:

- Drive motor horn (sounds on startup) ..... ( ) Yes ( ) No
Flashing red light when drive motor running:
Room 003 above door A ..... ( ) Yes ( ) No
Room 025 by pipe conduit ..... ( ) Yes ( ) No
Enabling switch lights ..... ( ) Yes ( ) No

2. Shielding Survey Site..... Reading at Surface (mr/hr)

- Zn Br Window .....
Interlocked Door A .....
Cable inlets near console .....
Room 025 .....
Instrument model and serial number .....

3. Remarks/Recommendations

\_\_\_\_\_
\_\_\_\_\_
\_\_\_\_\_

Signature \_\_\_\_\_



APPENDIX E  
University of Notre Dame  
SEMIANNUAL REPORT FOR VAN DE GRAAF NO. 2

Performed by: \_\_\_\_\_ Date: \_\_\_\_\_

Refer to Figure 2 (Van de Graaff No. 2 Facility Layout), Chapter 3, *Radiation Operations and Safety Manual*, for locations of items in this report.

**1. Operational Check**

The following interlocks, when disengaged by opening the gate or door, will stop the drive motor (observe that drive motor pilot light on console turns off):

- Interlocked Gate A ..... ( ) Yes ( ) No
- Interlocked Double Doors B ..... ( ) Yes ( ) No

The following devices (see Figure 2) stop or prevent the start of the accelerator by disrupting the continuity of the interlock system (You will be unable to activate drive motor, and pilot light will remain off):

- Photoelectric Eye ..... ( ) Yes ( ) No
- Emergency Stops
  - 1. (Chemical prep area) ..... ( ) Yes ( ) No
  - 2. (Room 012B) ..... ( ) Yes ( ) No
  - 3. (Vault by area monitor) ..... ( ) Yes ( ) No
  - 4. (Vault by sink, south wall) ..... ( ) Yes ( ) No
  - 5. (Vault southwest corner) ..... ( ) Yes ( ) No
- Enabling Switch ..... ( ) Yes ( ) No

The following devices give aural or visual indications of radiation production capability:

- Photoelectric Eye Alarm ..... ( ) Yes ( ) No  
(buzzes when system enabled and beam is broken)
- Enabling Switch Lights ..... ( ) Yes ( ) No  
(red for enabled; green for safe)
- Christmas Tree Board ..... ( ) Yes ( ) No  
(red for enabled; green for safe)
- Accelerator/Radiation ON Lights ..... ( ) Yes ( ) No  
(flashing when enabled; off when not enabled)

**2. Shielding Survey**  
(mr/hr)

Reading at Surface

Site: Interlocked Gate A \_\_\_\_\_  
 South Wall Room 006 \_\_\_\_\_  
 Instrument model and serial number \_\_\_\_\_

Remarks/Recommendations: \_\_\_\_\_

\_\_\_\_\_  
 \_\_\_\_\_

Signature \_\_\_\_\_



APPENDIX F
University of Notre Dame
SEMIANNUAL INTERLOCK VERIFICATION FOR THE LINEAR ACCELERATOR

Performed by: \_\_\_\_\_ Date: \_\_\_\_\_
Refer to Figure 3 (LINAC Facility Layout), Chapter 3, Radiation Operations and Safety Manual, for locations of the items mentioned in this report.

1. Operational Check

a. The following give aural or visual indications of interlock status and radiation readiness:

Warning Buzzer (15 seconds minimum when system enabled) Yes \_\_\_ No \_\_\_
Interlock Panel Lights on operator's console (Red = door open; interlock not satisfied. Green = door closed; interlock established. Both lights off = door partially open; interlock not satisfied.)

Steel Door #1 (Large)

Red Light Yes \_\_\_ No \_\_\_

Green Light Yes \_\_\_ No \_\_\_

Both Lights Off Yes \_\_\_ No \_\_\_

Steel Door #2 (Small)

Red Light Yes \_\_\_ No \_\_\_

Green Light Yes \_\_\_ No \_\_\_

Both Lights Off Yes \_\_\_ No \_\_\_

Steel Gate

Red Light Yes \_\_\_ No \_\_\_

Green Light Yes \_\_\_ No \_\_\_

Both Lights Off Yes \_\_\_ No \_\_\_

Modulator Room Door

Red Light Yes \_\_\_ No \_\_\_

Green Light Yes \_\_\_ No \_\_\_

Both Lights Off Yes \_\_\_ No \_\_\_

Red and Green Information & Warning Lights

(Red flashing = radiation production enabled or in progress. Green = safe to enter vault.)

Operational

Above the Console

Red Light Yes \_\_\_ No \_\_\_

Green Light Yes \_\_\_ No \_\_\_

**APPENDIX F**
**Operational**
**Outside the Double Steel Doors**

Red Light Yes \_\_\_\_\_ No \_\_\_\_\_

Green Light Yes \_\_\_\_\_ No \_\_\_\_\_

**In the Labyrinth**

Red Light Yes \_\_\_\_\_ No \_\_\_\_\_

Green Light Yes \_\_\_\_\_ No \_\_\_\_\_

**Next to Injector Housing**

Red Light Yes \_\_\_\_\_ No \_\_\_\_\_

Green Light Yes \_\_\_\_\_ No \_\_\_\_\_

Strobe Light (on Injector Housing) Yes \_\_\_\_\_ No \_\_\_\_\_

**South Wall (Accelerator Room)**

Red Light Yes \_\_\_\_\_ No \_\_\_\_\_

Green Light Yes \_\_\_\_\_ No \_\_\_\_\_

**Inside the Modulator Room Door**

Red Light Yes \_\_\_\_\_ No \_\_\_\_\_

Green Light Yes \_\_\_\_\_ No \_\_\_\_\_

Strobe Light (on Modulator Housing) Yes \_\_\_\_\_ No \_\_\_\_\_

- b. The following interlocks, when broken, disrupt the microwave power charging system. (“HV ENABLE” LED on trigger control panel at operator’s console will turn off. Listen for sound of shorting bar closing.)

Steel Door #1 (Large) Yes \_\_\_\_\_ No \_\_\_\_\_

Switch A Yes \_\_\_\_\_ No \_\_\_\_\_

Switch B Yes \_\_\_\_\_ No \_\_\_\_\_

Steel Door #2 (Small) Yes \_\_\_\_\_ No \_\_\_\_\_

Switch A Yes \_\_\_\_\_ No \_\_\_\_\_

Switch B Yes \_\_\_\_\_ No \_\_\_\_\_

Steel Gate Yes \_\_\_\_\_ No \_\_\_\_\_

Switch A Yes \_\_\_\_\_ No \_\_\_\_\_

Switch B Yes \_\_\_\_\_ No \_\_\_\_\_

Modulator Room Door Yes \_\_\_\_\_ No \_\_\_\_\_

Switch A Yes \_\_\_\_\_ No \_\_\_\_\_

Switch B Yes \_\_\_\_\_ No \_\_\_\_\_

- c. Operational Check of Key Switch Functionality

Operate/Standby Yes \_\_\_\_\_ No \_\_\_\_\_

Modulator Bypass (defeats specified interlock) Yes \_\_\_\_\_ No \_\_\_\_\_

System Bypass (defeats specified interlock) Yes \_\_\_\_\_ No \_\_\_\_\_

APPENDIX F

**2a. Shielding Survey** (to be performed under high-radiation conditions)

Specify conditions: \_\_\_\_\_  
\_\_\_\_\_

Site

Reading at Surface (mr/hr)

Double Steel Doors	_____
Operator's Console	_____
Modulator Room (waveguide)	_____
Modulator Room (floor cable inlets)	_____
Instrument Model and Serial Number	_____
Monitor Calibration Expiration Date	_____

**2b. Check for residual activity** – all components in the vicinity of the beam and target area. (To be performed with auxiliary system power turned off.)

**3. Stops** – The following emergency stops, when activated, both disrupt the microwave power charging system and disable auxiliary systems. (“AUX POWER” LED on trigger control panel at operator’s console will turn off. Cessation of pumps can be heard.)

Emergency Stop Switch #1 (Console)	Yes_____No_____
Emergency Stop Switch #2 (Modulator)	Yes_____No_____
Emergency Stop Switch #3 (Equip. Racks)	Yes_____No_____
Emergency Stop Switch #4 (Injector)	Yes_____No_____
Emergency Stop Switch #5 (South Wall)	Yes_____No_____
Emergency Stop Switch #6 (Accelerator Target)	Yes_____No_____

**4. Remarks/Recommendations:** \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Signature \_\_\_\_\_