HANDBOOK FOR PROTECTION AGAINST IONIZING RADIATION

FIFTH EDITION
1978

ISSUED BY:

RADIATION PROTECTION COUNCIL
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

HANDBOOK FOR PROTECTION AGAINST IONIZING RADIATION (REGULATIONS, RESPONSIBILITIES, AND PROCEDURES) NORTH CAROLINA STATE UNIVERSITY AT RALEIGH

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INTRODUCTION

This handbook has been prepared as a guide for North Carolina State University personnel involved in activities wherein radioactive materials and/or ionizing radiation producing devices are used. The purpose of this handbook is to set forth regulations, responsibilities, and procedures for such uses which will insure that the resulting radiation exposure is no greater than that which is warranted when the benefits from the use and the associated risks are properly balanced. In this connection, every effort will be made to keep such exposures as far below the legal limit as is reasonably achievable.

North Carolina State University has been issued licenses by the State of North Carolina through the Radiation Protection Section of the Division of Facility Services and from the federal government through the Nuclear Regulatory Commission. These licenses govern the acquisition, use, and disposal of radioactive materials and radiation producing devices on the campus. To meet the conditions of the licenses, the Radiation Protection Council was established to institute the radiation protection program hereinafter described.

The Radiation Protection Council carries out its duties with the attitude of encouraging new and worthwhile uses of radioactive materials and/or ionizing radiation producing devices while being continuously vigilant in its efforts to maintain and improve radiation safety practices to minimize exposures. The Council recognizes at the outset that its program will be successful only if it is fully supported in spirit and in fact by the users. To this end, the Council promotes educational programs to develop a clear understanding of the principles of radiation protection and endeavors to insure that there is an atmosphere of confidence and mutual trust between the Council, the Radiation Protection Office, and the user.

SECTION 1 ADMINISTRATION

1.1 Radiation Protection Council

The Radiation Protection Council has been established to insure that uses of radioactive materials and/or ionizing radiation producing devices, including the nuclear reactor, on the North Carolina State University campus and/or extension sites are conducted in the safest possible manner. The Council is directly responsible to the University Administration so that the provision exists for making technical judgments and recommendations that are free from departmental influences which may not be in the best interest of the program.

The Council consists of at least ten voting members from the general faculty. Nine of these members are appointed annually by the University Administration; the tenth member is appointed by the Faculty Senate as a representative from that body. The Radiation Protection Officer, Associate Radiation Protection Officer, and the Director of the Safety Division serve as ex officio members. In addition, a representative is appointed from both the Physical Plant Division and the University Research Administration to serve in a liaison capacity. One of the voting members is designated as Chairman and another as Vice Chairman. The Chairman normally serves for two years with the Vice Chairman succeeding to the position of Chairman. These two positions usually rotate among the represented schools and divisions of the University.

Members of the Council are selected primarily from the faculty who are actively engaged in teaching and research involving the use of radioactive materials and/or ionizing radiation producing devices. As a result, most members will be individuals who manifest a high degree of expertise in the areas of nuclear science and in the related fields of the physical and biological sciences. The unit of representation on the Council is at the school and/or division level. Generally, two faculty members are selected from each school which is concerned in some measure with ionizing radiation. Members may succeed themselves with terms of service normally being four years. Reappointment of members is made with the idea in mind of maintaining a majority of returning members so that continuity of Council practices may be insured.

The Council normally meets each month but does not meet less than six times per year. In addition to the regular meetings, the Chairman may call special meetings when circumstances warrant this action. The proceedings of all meetings are duly documented and distributed so as to keep the appropriate schools, departments, divisions, and/or offices of the University appraised of Council actions.

The University has been issued licenses from the responsible state and federal agencies to utilize a broad range of radioactive materials and/or ionizing radiation producing devices. In order for the University to enjoy the advantages of this broad-use concept, it must establish the mechanism by which it, in effect, regulates and controls itself. The Council has been established as that University agency to which this regulatory authority has been given. This authority includes the promulgation of the regulations, responsibilities, and procedures which follow in this handbook.

The Council discharges its responsibilities with the attitude that a spirit of mutual trust exists between the Council and the user. However, to guard against oversight and human fallibility, the Council must maintain the authority to require:

a. that users strictly adhere to the procedures set forth in this handbook and the approved project application;
b. that users allow such monitoring of their work as is necessary to insure that the work is radiologically safe; and
c. that users understand that the Council's agent, the Radiation Protection Officer, may suspend approval for use when circumstances warrant this action. The Council may at its discretion require a re-application for use if this circumstance arises. When such action is taken, every effort will be made by the Council and the Radiation Protection Officer to re-establish the approval in the most expeditious and straightforward manner possible.

In the discharging of its duties, including the preparation of this handbook, the Council takes the position that it may establish regulations and procedures which may be more conservative than those of the State of North Carolina and/or the Nuclear Regulatory Commission.

1.2 Radiation Protection Officer

A Radiation Protection Officer is appointed by the University Administration to be directly responsible to the Radiation Protection Council and to serve independently of any school, department, or division. An Associate Radiation Protection Officer works closely with the Radiation Protection Officer and is given the same authority when circumstances dictate. These individuals must be able to meet the qualifications for certification as set forth by the American Board of Health Physics or its acceptable equivalent.

In the absence of the Radiation Protection Officer,

the Associate Radiation Protection Officer automatically assumes all of the authority and responsibilities of the Radiation Protection Officer's position. In the absence of both these individuals, the Chairman of the Radiation Protection Council will appoint an Acting Radiation Protection Officer.

The Radiation Protection Officer is responsible for insuring that users of radioactive materials and/or ionizing radiation producing devices adhere to appropriate federal, state, and Radiation Protection Council regulations. In addition to this, the Radiation Protection Officer is to advise and assist users in the development of new and worthwhile programs utilizing ionizing radiation.

1.2.1 Radiation Protection Office

In addition to the Radiation Protection Officer and Associate Radiation Protection Officer, the University has provided for the establishment of various technical and clerical staff positions, items of specialized equipment, and space to constitute an official University office designated as the Radiation Protection Office.

This office provides as a service to the University those activities, both administrative and technical, which are necessary to insure adherence to the regulations, responsibilities, and procedures set forth in this handbook. The Radiation Protection Officer serves as the director of the Radiation Protection Office and in this sense the authority of this Office is solely vested in this individual. Specific activities of the Radiation Protection Office include the following:

a. Perform the initial review of all applications for permission to obtain and use radioactive materials and/or ionizing radiation producing devices. This includes working closely with a potential user during the planning phase of the proposed work, i.e., inspection of the laboratory spaces, training of personnel who will be working with the user in charge, and helping the user to develop appropriate handling techniques. Certain uses (see Section 2.1.6 of this handbook) are exempt from formal review by the Radiation Protection Council; the determination of whether or not this exemption applies is made by the Radiation Protection Officer.
b. Mark and post laboratories wherein radioactive materials and/or ionizing radiation producing devices are to be utilized as per the applicable federal and state regulations. In this connection, it is also the responsibility of the Radiation Protection Office to provide users with certain forms for documentation purposes; these include, but are not limited to, forms entitled "Personnel Monitoring Service" and "Quarterly Radioactive Materials Inventory."
c. Provide the necessary radiation monitoring services including personnel monitoring, contamination surveys, radioactive waste disposal, radiation surveys, survey meter calibration, etc. Adequate services are provided to supplement and confirm the sufficiency of the handling procedures; this includes periodic inspections of the various laboratories to insure that activities are in accordance with the provisions of the approved project application. In some cases special services are furnished such as providing a survey technician to directly monitor a critical operation.
d. Provide environmental radiation surveillance including analysis of air, water, foliage, and foodstuffs to insure that uses of the radioactive materials and/or ionizing radiation producing devices at North Carolina State University do not degrade the environment.
e. Maintain complete and accurate records including results of radiation monitoring and surveillance activities, transactions of the Radiation Protection Council and the Reactor Safeguards Advisory Group, government regulations, radioactive materials licenses, etc.
f. Conduct training courses for personnel involved in radiation work.
g. Maintain a capability to deal with any emergencies that may arise due to the use of radioactive materials and/or ionizing radiation producing devices on the campus of North Carolina State University.

In the performance of these duties, the Radiation Protection Officer must insure that the Radiation Protection Office staff does not adopt the role of "policemen" as a standard way of doing business. The end result is to maintain ionizing radiation exposure at the lowest practical level in an atmosphere of mutual trust and cooperation between the user and the Radiation Protection Office.

1.3 Authorized User in Charge

Each project using radioactive materials and/or ionizing radiation producing devices must be under the direction of an individual designated as the Authorized User in Charge. This individual must be a permanent faculty or staff member of North Carolina State University. The Radiation Protection Council assigns to this individual the responsibility for insuring that work with radioactive materials and/or ionizing radiation producing devices conforms to the description of use as stated in the approved project application and to the appropriate sections of this handbook. In this connection, the Authorized User in Charge:

a. Submits a written request for all new uses of

radioactive materials and/or ionizing radiation producing devices via the form entitled "Application for Permission to Obtain and/or Utilize Materials or Devices which Emit Ionizing Radiation" (Appendix A to this handbook).

b. Submits a written request for approval to make changes to existing projects when such changes introduce potential hazards that are as yet unreviewed by the Council.

c. Notifies the Radiation Protection Office of additions or deletions to the list of project personnel as such changes take place and also furnishes a current list of project personnel along with the quarterly inventory of radioactive materials. Where appropriate, the Authorized User in Charge submits a request for "Personnel Monitoring Service" form for each individual who will be subject to ionizing radiation exposure. The Authorized User in Charge also insures that project personnel cooperate fully with the Radiation Protection Office in the performance of any bioassay or medical procedures which may be necessary to assess internal exposure.

d. Insures that all project personnel understand that radioactive materials and/or ionizing radiation producing devices are to be used only as described in the approved application for use. The Authorized User in Charge also insures that project personnel follow recommended safety practices to minimize exposure to themselves and prevent, to the extent possible, the spread of contamination. In this connection, the Authorized User in Charge insures that all project personnel understand that the Radiation Protection Office is to be notified immediately if accidents occur in the laboratory wherein radioactive materials and/or ionizing radiation producing devices are used.

e. Keeps an up-to-date log of use and inventory of all radioactive materials for which he has charge and submits such an inventory to the Radiation Protection Office on a quarterly basis.

f. Notifies the Radiation Protection Office of any unusual hazards in the laboratory area which could affect the safety of the Radiation Protection Office staff while engaged in their surveillance work, e.g., the handling of waste materials having a degree of toxicity (in addition to radioactivity) which would necessitate special handling procedures. Special hazards due to mechanical or electrical equipment should also be brought to the attention of the Radiation Protection Office.

g. Insures that no materials and/or devices are utilized by unauthorized users.

h. Submits a written request to the Radiation Protection Officer for the assignment of an Acting Authorized User in Charge to take over the project responsibilities when the Authorized User in Charge must be absent from the University for an extended period of time. The individual who is to assume project responsibilities must be a member of the faculty or staff of the University and also have training and experience comparable to that of the Authorized User in Charge. If such an individual is not assigned, the radioactive materials and/or ionizing radiation producing devices covered by the project(s) shall not be used but shall be placed in an approved storage area.

1.4 Nuclear Reactor Facility

Because of the increased potential for exposure to ionizing radiation from the operation of the nuclear reactor, assurances must be made that an appropriate administration is maintained to oversee these operations. A full description of the responsibilities of reactor facility administrators is contained in the Nuclear Regulatory Commission license documents, in particular, the technical specifications. The discussion which follows describes these responsibilities and lists those specific additional duties which are required by the Radiation Protection Council.

1.4.1 Nuclear Operations Administrator

The Nuclear Operations Administrator is responsible for the safe and efficient operation and utilization of the nuclear reactor facility. This responsibility includes the special nuclear material associated with the use of the reactor such as stored nuclear fuel elements, startup sources and fission chambers. In all matters pertaining to the operation of the facility, the Nuclear Operations Administrator reports to and is directly responsible to the Head of the Department of Nuclear Engineering. The Nuclear Operations Administrator with the assistance of the reactor operations and maintenance staff has the following duties:

a. Reviews all experiments utilizing the nuclear reactor to assure compliance with the provisions of the facility license, technical specifications, and Nuclear Regulatory Commission regulations and makes recommendations based on this review to the Radiation Protection Council for its use in consideration of new and/or untried experiments.

b. Insures that all changes to the facility and all changes to the established operating procedures are appropriately reviewed, evaluated, and approved as per the provisions of the facility license and the technical specifications, and further insures that such changes are appropriately documented.

c. Maintains records associated with the operation

and maintenance of the reactor and its supporting facilities including records of all irradiations.

d. Informs the Radiation Protection Office of all non-routine operations and manipulations which could result in significant personnel exposure or increase the likelihood that a reactor safety system setting could be exceeded. In this connection, the Nuclear Operations Administrator reports to the Radiation Protection Office any accidents involving exposures, spills and/or leaks that result in a potential radiation risk.

e. Meets periodically with the Reactor Safeguards Advisory Group so that they may jointly review the operations and maintenance activities associated with the reactor.

f. Insures that the reactor is not operated in any manner which is not authorized including the irradiation of any materials, substances, plants, or animals without the assurance that the individual requesting such irradiations has received appropriate approval from the Council.

g. Submits a monthly written report to the Council concerning the operation of the reactor from the viewpoint of safety, setting forth, but not limited to, a description of:
   1. the quantity of radioactive material released to the environs;
   2. all accidents involving significant exposures, spills, or leaks;
   3. unscheduled automatic activation of the confinement or evacuation systems;
   4. non-routine operations or manipulations which resulted in significant personnel exposures and/or the exceeding of a reactor safety system setting.

1.4.2 Reactor Health Physicist

The Reactor Health Physicist is responsible for assuring the safety of reactor operations from the standpoint of radiation protection. This responsibility includes the radiation monitoring and accountability measures associated with any special nuclear material used in the Department of Nuclear Engineering. This individual performs such duties independently of the reactor operations group and is responsible to and reports to the Head of the Department of Nuclear Engineering. The duties of the Reactor Health Physicist include the following:

a. Reviews and evaluates requests for reactor operations from the standpoint of radiation protection in the manner prescribed in the Nuclear Regulatory Commission approved reactor operating procedures, facility license, and technical specifications.

b. Determines exposure levels for various operations and manipulations and also determines the exposure time for the personnel involved. The Reactor Health Physicist will not, except in case of emergency, permit greater exposure to personnel than is consistent with the provisions of Section 3 of this handbook. In this connection, the Reactor Health Physicist reports immediately to the Radiation Protection Office any exposure in which a person or persons may have:
   1. exceeded the weekly maximum permissible exposure of 100 millirems in any seven-day period;
   2. received as much as the weekly permissible exposure in any 24-hour period;
   3. or for the case of persons under 18 years of age, received as much as ten percent of the weekly maximum permissible exposure.

c. Serves as an advisor for users of the reactor facility in helping them to meet the conditions of Section 2 of this handbook, in particular, Sections 2.1 and 2.3.

d. Provides radiation safety training to faculty, staff, students, and other personnel who utilize the reactor facility as required under Section 2.1.1.1 of this handbook, the regulations of the State of North Carolina, and the Code of Federal Regulations.

e. Performs or causes to be performed a program of reactor effluent monitoring sufficient to be able to account for the activity in and isotopic content of all reactor effluents as prescribed in the facility license and technical specifications.

f. Monitors the condition of the reactor and its designed safety features, such as the biological shield, from a radiation safety point of view so that it may be insured that no deterioration is taking place.

g. Works with the Nuclear Operations Administrator to furnish the necessary information for preparation of the monthly reactor safety report to the Radiation Protection Council.

1.5 Reactor Safeguards Advisory Group

The Reactor Safeguards Advisory Group consists of four persons. Three of these persons are appointed by the University Administration upon the recommendation of the Radiation Protection Council. Such appointments are made for three years with one appointment being made each year. Reappointment of members is permitted. One of these persons shall be designated as Chairman. The Associate Radiation Protection Officer serves as the fourth member. In this capacity, the Associate Radiation Protection Officer is a permanent, voting, ex officio member serving both as an advisor in the area of interpretation of and adherence to Nuclear Regulatory Commission

approved reactor documents and as secretary to the Group.

The Reactor Safeguards Advisory Group serves as a permanent advisory committee to the Radiation Protection Council to review those phases of reactor operations including experimental uses for which the Council requires the Group's particular expertise. The Group also serves a function which is independent of the Council in that it must conduct objective appraisals of reactor procedures and operations. These appraisals are to be performed at least every six months. The results of these investigations are to be reported to the Nuclear Operations Administrator and to the Council at its next meeting. At the discretion of the Group, specialists from other universities and outside establishments may be invited to assist in these appraisals.

Reference is also made to the current technical specifications and facility license for the reactor which further define the functions of the Reactor Safeguards Advisory Group.

SECTION 2 APPLICATION FOR USE, PROCUREMENT, UTILIZATION, AND DISPOSAL OF RADIOACTIVE MATERIALS AND/OR IONIZING RADIATION PRODUCING DEVICES

2.1 Application for Use

With the exception of the provisions of Section 2.1.6 of this handbook, application for permission to obtain and/or utilize materials or devices which emit ionizing radiation shall be made by completing Form RPO-1. (For reference a copy of this form is included as Appendix A to this handbook; forms to be submitted may be obtained from the Radiation Protection Office.) The application procedure should be as follows:

a. Contact the Radiation Protection Officer and/or the Associate Radiation Protection Officer to arrange for a meeting to discuss the proposed work and to allow for the inspection of the intended laboratory or space where the work is to be performed. This meeting serves the purpose of allowing the Radiation Protection Officer to become familiar with the proposed work, to render any guidance and assistance which may be useful in planning the proposed work, and if necessary, to inform the applicant of any special steps which may need to be taken to prepare for the use of ionizing radiation. This includes such items as training of personnel, modification of laboratory facilities, or addition of new equipment such as the installation of a radiochemical fume hood. Finally, detailed instructions will be provided for completing the project application form and any questions the applicant may have with respect to the required information will be answered.

b. Submit the original plus four copies of Form RPO-1 along with any supplementary material to the Chairman of the Radiation Protection Council. The permanent mailing address of the Radiation Protection Council is the same as that of the Radiation Protection Office; therefore, the material should be mailed or delivered to Room 214 David Clark Laboratories which is located on Brooks Avenue on the North Carolina State University campus. The project application will be placed on the meeting agenda for consideration by the Radiation Protection Council as per Section 2.1.7 of this handbook.

2.1.1 Project Personnel

The project application (Form RPO-1) requests information regarding those personnel who are to utilize radioactive materials and/or ionizing radiation producing devices under the proposed project.

The project application must first of all name the Authorized User in Charge. A full description of the responsibilities of this individual is given in Section 1.3 of this handbook. To summarize, the Authorized User in Charge has the responsibility for insuring that the work with radioactive materiels and/or ionizing radiation producing devices conforms to the description of use as stated in the approved project application and to the appropriate sections of this handbook. Further, the Authorized User in Charge must be a permanent faculty or staff member of North Carolina State University. The experience of the Authorized User in Charge as it relates to the utilization of ionizing radiation is requested on the application form; this information provides the Radiation Protection Council with the basis for determining if the applicant has the experience and ability to cope with the hazards involved in the particular application.

Certain data is required for all personnel who will be working under the proposed project including each person's name, age, and previous exposure history. With the exception of those limitations listed under Section 3.1.1.3 of this handbook, any faculty member, staff member, student of North Carolina State University, or other specially authorized person, who has received proper training and orientation in the use of ionizing radiation, may be included in the list of project personnel. The Authorized User in Charge must keep this list current and insure that all project personnel are properly trained. The project personnel list is to be updated at least every calendar quarter on a form supplied by the Radiation Protection Office.

2.1.1.1 Personnel Training

In order to guarantee effective compliance with the procedures and requirements listed on the approved project application and in this handbook, the Radiation Protection Office shall provide general instruction with regard to radiation hazards, contamination hazards, and protective methods to personnel working with radioactive materials and/or ionizing radiation producing devices. This instruction shall take place directly in the laboratory and also during formal training sessions conducted by the Radiation Protection Office. Such training sessions are normally held at the beginning of each academic term and at other times as special needs may arise.

Additional training for persons utilizing the nuclear reactor facility will be provided by the Reactor Health Physicist. This training will be sufficient

to meet the conditions of the facility license and appropriate federal regulations and will cover such items as response to emergency situations.

The Authorized User in Charge has the ultimate responsibility for insuring that project personnel are properly trained in radiological safety. This responsibility includes insuring that all project personnel are scheduled for training sessions as provided by the Radiation Protection Office and insuring that each person is familiar with the approved project procedures. The Authorized User in Charge must further insure that each user is proficient in the manipulative techniques which are associated with the work including the operation of various pieces of specialized equipment.

Appendix C to this handbook provides a partial listing of publications on regulations, standards, and principles of radiation protection. Users should become familiar with the contents of these publications as they apply to their specific work.

2.1.2 Unsealed Sources of Radioactive Material

An unsealed source of radioactive material is one with which physical contact may be made to dilute, mix, sub-divide, or otherwise manipulate the source. Radioactive material in a screw-cap vial or other similar sample holder is considered unsealed.

When making application for permission to obtain and use radioactive material in the unsealed form, the applicant will set forth clearly the radioactive material desired, the maximum quantity for possession, the description of use, and the final disposition. This information is supplied by completing Section 3.1 of the project application form RPO-1. The supplementary sheet RPO-1(S), which appears as Appendix B to this handbook, lists as a minimum that information which must be supplied to describe the use of the unsealed radioactive material. The information requested by RPO-1(S) includes a description of the work areas, storage areas, manipulations to be performed, handling procedures, duration of work, and quantity of radioactive waste; other information which provides insight into the radiological safety aspects of the work should also be attached.

2.1.3 Sealed Sources of Radioactive Material

A sealed source is one which has been encapsulated in an impervious shell or jacket such as stainless steel which has been welded or otherwise permanently sealed closed. The integrity of the source seal must be of such quality that when leak tested, the amount of removable contamination does not exceed limits specified in the University's Radioactive Material License. Examples of sources which are usually sealed are radium, Cobalt-60, and Cesium-137 gamma calibration sources. Polonium-210, Plutonium-239, and Americium-241 are usually unsealed sources when used as alpha emitters, but they may be sealed when mixed with beryllium and used as neutron and/or gamma sources.

An applicant for the use of a sealed source of radioactive material will provide the same information described in Section 2.1.2 of this handbook. The information supplied in this case, however, must obviously give emphasis to the description of the external radiation hazards and the techniques used to reduce these hazards to acceptable levels. A full description of the material used for the source seal and the method used for making the seal (i.e. type weld, application of epoxy resins, etc.) must be supplied for each sealed source. A detailed drawing of the source is also required.

For large sealed sources, such as commercial or pool type irradiators that are capable of generating very high dose rates, the following information must also be supplied:

a. a full description of the design of the facility including an analysis of the adequacy of the shielding material,
b. a full description of the location of the facility including special features such as safety interlocks,
c. the operating procedures including a description of operational features which are intended to make the unit failsafe, and
d. an analysis of the consequences of the various emergencies which can be postulated along with a statement of actions which will be taken to mitigate these emergencies.

Under some circumstances sources may meet all the conditions of being sealed; however, by the very nature of their intended use, the seal is made very thin to allow passage of low energy or particulate radiation through the seal. In this case, the source handling procedures, particularly those related to protection of the fragile seal, become very important and must be addressed in detail in the project application. Considerations of internal exposure also become very important for uses of this type of sealed source because of the potential for loss of seal integrity and the resultant spread of contamination.

2.1.4 Ionizing Radiation Producing Devices

Ionizing radiation producing devices are those which emit ionizing radiation due to difference of potential but not by decay of radioactive material. Application for permission to use such a device is made by submitting Form RPO-1 (Appendix A to this handbook) to the Radiation Protection Council. Section 3.2 of the application form is in two parts, namely X-Ray Machines and Accelerators. Specific characteristics of the device to be used are provided

by completing the appropriate part of Section 3.2 of the application form.

Section 3.2.1 of the application form lists the information required for making application for use of an x-ray machine. In most cases this information will be sufficient; however, uses of the machine in a non-standard or untried manner may require additional information which will be defined by the Radiation Protection Officer at the time of the initial contact in the application process.

As indicated on the application form, devices which produce x-rays as a by-product, such as plasma devices, electron microscopes, etc., are covered by the regulations in this handbook. If questions exist as to whether a piece of equipment is to be considered as a source of x-rays when in use, the Radiation Protection Officer should be contacted.

Section 3.2.2 of the application form lists the information required for making application for use of a particle accelerator. Any additional information which may be required will be defined by the Radiation Protection Officer at the time of the initial contact for application for use. In this connection, it is advisable to consult the Radiation Protection Officer early in the planning stages for the use of these devices to provide for the greatest possible radiological safety input and to avoid costly changes or backfitting at a later date.

2.1.5 Nuclear Reactor Facility

Utilization of the nuclear reactor must be in conformity with all the conditions of the Nuclear Regulatory Commission reactor facility license and the various documents which support this license, most specifically, the technical specifications. The operation of the reactor in the standard and prescribed manner merely as a means to generate a neutron field of known magnitude is inherently permitted under the facility license. However, any proposed operation of the reactor in a new and untried manner must receive all of the reviews as prescribed in the technical specifications and ultimately be approved by the Radiation Protection Council before being performed. A request to perform reactor operations of this type is made by completing the appropriate sections of Form RPO-1 (see Appendix A to this handbook). After completion, the application form is submitted to the Nuclear Operations Administrator and other appropriate Department of Nuclear Engineering personnel for review as required by the technical specifications. The Nuclear Operations Administrator will transmit the proposal, along with any recommendations which have resulted from this review, to the Chairman of the Radiation Protection Council. For certain uses, approval of the Nuclear Regulatory Commission will be required; the Radiation Protection Council will determine when this level of approval is necessary.

The application form does not specify the detailed information which is to be submitted in support of a given proposed reactor use. These details will be specified or determined in consultation with the Nuclear Operations Administrator and/or the Radiation Protection Officer at the time the request for approval is actually being prepared. As a minimum, however, this description of reactor use must provide an analysis of the extent to which such a use may cause the operational parameters of the reactor to approach limiting values or the extent to which uncontrolled releases of radioactivity may occur. The safety precautions which shall be instituted to mitigate these effects must also be described.

The use of the reactor to produce certain radioactive materials which are then to be used under an approved radioactive materials project is permitted under approval previously obtained by the Department of Nuclear Engineering. A full discussion on the requirements for receipt of such materials is covered in Section 2.2.4 of this handbook.

2.1.6 Exempt Quantities and Exceptions to the Application Procedure

Certain uses of radioactive material because of the quantity and form of the material involved and/or the experience of the user are exempt from the application procedures previously discussed in this handbook. These exemptions are:

a. For users with experience in using radioactive materials under a previously approved project, the Radiation Protection Officer may grant approval for:
   1. The procurement and use of any beta and/or gamma emitting radioactive materials covered by the following table:

Effective Half-life	Approval Quantity
i. greater than one year	100 x Maximum Permissible Body Burden or one millicurie, whichever is smaller
ii. greater than 30 days but less than one year	1000 x Maximum Permissible Body Burden or five millicuries, whichever is smaller
iii. less than 30 days	10000 x Maximum Permissible Body Burden or ten millicuries, whichever is smaller

   2. The procurement and use of up to 6.8 kg of natural uranium and thorium compounds.
   3. The transfer of responsibility for existing projects between approved Authorized Users in Charge.
   4. The transfer of radioactive materials between approved projects.

   Such approvals as are granted by the Radiation Protection Officer are recorded and then reported

at the next meeting of the Radiation Protection Council.

b. The Radiation Protection Council hereby grants approval to any faculty member or staff member of North Carolina State University to obtain and use radioactive materials in the quantities listed below without the prior approval of the Council or the Radiation Protection Officer:
   1. Unsealed beta and/or gamma emitting radioactive materials in quantities not exceeding one microcurie.
   2. Unsealed alpha emitting radioactive materials in quantities not exceeding 0.01 microcuries.
   3. Natural uranium and thorium compounds for use as analytical reagents in quantities not exceeding 0.01 microcuries (purchase of stock quantities of such compounds to be possessed by departments for dispensing must be cleared with the Radiation Protection Officer).

Even though the use of these materials is exempt from prior approval by the Radiation Protection Council, the procurement of these materials must be coordinated with the Radiation Protection Officer as per Section 2.2 of this handbook; and further, the use of such materials must be conducted in a manner consistent with the radiological safety considerations as are presented in Section 2.3 and Section 3 of this handbook. Also, when such radioactive materials are no longer of use, they must be turned over to the Radiation Protection Office for disposal as radioactive waste.

2.1.7 Review and Approval of Project Application

After completion, the application for permission to use radioactive materials and/or ionizing radiation producing devices is transmitted to the Radiation Protection Office (214 David Clark Laboratories). The application is next reviewed in detail by the Radiation Protection Officer. Even though the Radiation Protection Officer will be familiar with the proposed work due to interaction with the applicant during the planning stages, the applicant may at this point be requested to provide additional information or to perform "cold run" operations under the Radiation Protection Officer's supervision so that the adequacy of the proposed handling procedures can be determined. The Radiation Protection Officer will make a formal recommendation with regard to granting or denying approval and may attach recommended conditions or stipulations regarding the use if such is judged to be necessary. The application is transmitted to the Radiation Protection Council members for their review and formal consideration at the next scheduled Council meeting. The Chairman may call a special meeting to consider this request if circumstances warrant this action.

Radiation Protection Council approval of any proposed usage of radioactive materials and/or ionizing radiation producing devices will be based on the adequacy of the safety measures to be exercised. Three principal factors are considered by the Council in evaluating the adequacy of the safety provisions in a proposed usage: (i) the experience and ability of the applicant to cope with the hazards involved in the particular application, (ii) the adequacy of the facilities and equipment for the proposed usage, and (iii) the thoroughness and attention given to safety precautions in the proposed experimental manipulations and disposal techniques.

The Council may request additional information, special tests, or trial runs which may be necessary to confirm the adequacy of the radiological safety precautions. The Council may also specify further safety measures or otherwise condition its approval for certain types of operations and for particular projects.

The Council has final judgment as to the approval of an application for the use of radioactive materials and/or ionizing radiation producing devices. Approval of the application for use requires a two-thirds majority vote of the Council. In making its decision, the Council is guided by the report of the Radiation Protection Officer as to the radiological risks and hazards involved and the procedures designed to minimize these risks and hazards.

The University does not have authority to approve the utilization of radioactive materials wherein human subjects are involved or experiments which result in the widespread distribution of radioactive materials. In these cases approval must be obtained from the State of North Carolina through the Radiation Protection Section of the Division of Facility Services and/or the Nuclear Regulatory Commission.

The applicant will be notified by the Radiation Protection Office whether the application for use is approved or not approved. If the application for use is not approved, the Council will indicate the additional information to be supplied and/or the additional safety measures which must be included in the experimental procedures so that the application may receive further consideration. If approved, a project number will be assigned and the applicant will receive a copy of the approved application form along with any stipulations or conditions of approval. The method by which changes and amendments to existing projects may be effected is discussed fully in Section 2.1.9 of this handbook.

2.1.8 Establishment of Radiation Monitoring Program in Laboratory or Place of Work

After an application for the use of radioactive materials and/or ionizing radiation producing

devices is approved, the Radiation Protection Office institutes the necessary radiation surveillance activities to insure the continued safety of both the laboratory personnel and the general University population. The actual monitoring activities will depend on the type and level of use; as a minimum, however, the Radiation Protection Office will perform the following:

a. Post, mark, or otherwise delineate the work space as an area set aside for utilization of radioactive materials and/or ionizing radiation producing devices.
b. Post copies of certain license required documents such as "Notice to Employees" signs in the work space. This notice informs employees working in this area of regulations under which radioactive materials and/or ionizing radiation producing devices are being used and the rights of such employees to inspect all license documents.
c. Post any emergency procedures which may be required and insure that operating procedures for ionizing radiation producing devices are posted.
d. Provide the user with specially marked containers for the radioactive wastes that will be generated. This includes liquid and solid waste containers. Biological wastes and any other special forms of wastes will be handled on a case-by-case basis in a manner most suitable to the particular needs of a given laboratory.
e. Provide personnel monitoring devices for all users where appropriate and institute bioassay procedures or other internal dosimetry procedures where applicable.
f. Commence a program of routine, periodic radiation monitoring for control of contamination and radiation levels in all work spaces.
g. Evaluate the performance of fume hoods used in work with radioactive materials on a periodic basis to insure that these hoods continue to operate in the manner which is adequate to provide the intended safety function.
h. Provide the necessary documents and forms to the Authorized User in Charge so that the radioactive materials inventory and list of project personnel may be kept current.

2.1.8.1 Classifications of Laboratories

The laboratory or work space wherein radioactive materials and/or ionizing radiation producing devices will be used shall be classified according to the quantity of radioactive materials to be used or the level of radiation which will be generated in the area. Caution signs, labels, and markers, as defined below, will be used to classify such areas.

Restricted Area—any area to which access is controlled for the purpose of protection of individuals from exposure to ionizing radiation and radioactive materials.

Radiation Area—any area accessible to individuals in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of five millirems or in any five consecutive days a dose in excess of 100 millirems.

High Radiation Area—any area accessible to individuals in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirems.

Airborne Radioactivity Areas—(i) any room, enclosure, or operating area in which airborne radioactive material exists in concentrations in excess of the amounts specified in Appendix A, Table I, Column 1, Part C of the North Carolina Regulations for Protection Against Radiation; or (ii) any room, enclosure or operating area in which airborne radioactive material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix A, Table I, Column 1, Part C of the North Carolina Regulations for Protection Against Radiation.

Caution—Radioactive Materials—(i) each area or room in which any radioactive material, other than natural uranium or thorium, is used or stored in an amount exceeding the quantity of radioactive material specified in Appendix B, Part C of the North Carolina Regulations for Protection Against Radiation shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words "Caution—Radioactive Materials;" or (ii) each area or room in which natural uranium or thorium is used or stored in an amount exceeding 100 times the quantity specified in Appendix B, Part C of the North Carolina Regulations for Protection Against Radiation shall be posted with a sign or signs bearing the radiation caution symbol and the words "Caution—Radioactive Materials."

Laboratories may be classified further as to the level of radioactivity to be utilized in the laboratory or work space. The three classifications which follow specify the type of laboratory equipment which must be available for use of a given level of radioactive material.

2.1.8.1.1 Low Level Laboratories

Special laboratory facilities will generally not be required when the total amount of activity of a single radioactive material being used at any time does not exceed the value given in Appendix B, Part C of the

North Carolina Regulations for Protection Against Radiation. For a mixture of radioactive materials, the limiting value shall be calculated according to the method outlined in the North Carolina Regulations for Protection Against Radiation. Although special facilities will not always be mandatory for low level laboratories, the usual good practices applicable to all radioactive material laboratories as are described in Section 2.3.1 of this handbook shall be implemented. For example, use of the laboratory shall be limited to those persons and to the specified conditions indicated in approved projects; the no smoking, eating, or drinking rule shall be observed; pipetting by mouth is forbidden; etc. In addition, the standard equipment necessary for all radioactive material handling operations, such as protective gloves, stainless steel trays, and appropriate monitoring equipment shall be employed.

Usually one wishes to procure an amount of a radioactive material that is in considerable excess of the quantity that will be used at any one time. When the amount procured is greater than that allowed for use in a low level laboratory, the initial dilutions and separations into aliquots shall be made in a fume hood approved for radioactive work. Three ways in which this can be accomplished are: (i) the user can borrow hood space from another staff member working with radioactivity; (ii) the user can request the Radiation Protection Office to arrange for the use of a hood; (iii) the user can request the Radiation Protection Office to perform the initial dilution.

2.1.8.1.2 Intermediate Level Laboratories

When the amount of activity to be used exceeds the values given in Appendix B, Part C of the North Carolina Regulations for Protection Against Radiation, operations shall center in a high quality fume hood. The hood surfaces shall be easily decontaminated or should be considered expendable. A negative pressure shall be maintained in the ducts whenever the spread of contamination is to be avoided and the output of the blower shall be arranged so as not to present a hazard to others.

The average concentration of activity at the blower output shall not exceed the following conditions:

a. For releases taking place over a time not exceeding 24 hours:
   1. **500 times the unrestricted area maximum permissible concentration value for radioactive materials with half-life of one day or less;**
   2. **300 times the unrestricted area maximum permissible concentration value for radioactive materials with half-life of seven days or less;**
   3. **50 times the unrestricted area maximum permissible concentration value for radioactive materials with half-life of 30 days or less;**
   4. **10 times the unrestricted area maximum permissible concentration value for radioactive materials with half-life greater than 30 days.**
b. For releases averaged over a year, the concentration shall not exceed the unrestricted area maximum permissible concentration value.

The laboratory should be a high-grade chemical laboratory with non-absorbent or disposable working surfaces, non-absorbent floor coverings, and non-absorbent wall surfaces that are easy to decontaminate.

Additional procedures and equipment necessary for maintenance of radiological safety may be recommended for project applications wherein intermediate level type work is to take place.

2.1.8.1.3 High Level Laboratories

Each particular use of a large quantity of radioactive materials will require specially designed facilities and equipment for which general descriptions are not available. Each such use will receive detailed consideration by the Radiation Protection Council.

2.1.9 Amendment to Existing Projects

If a user wishes to perform work under an existing project which in effect alters the scope of the project to the extent that new radiological risks and hazards may be generated, then the Authorized User in Charge must send a written project amendment request to the Radiation Protection Officer for review. If the scope of the amendment falls within the conditions for approval specified under Section 2.1.6 of this handbook, the amendment request may be approved directly by the Radiation Protection Officer. Such approvals are recorded and then reported at the next Radiation Protection Council meeting.

If the amendment to the project involves the use of quantities of radioactive materials in excess of those specified in Section 2.1.6 of this handbook or if the proposed change to work involves new handling techniques or modes of use which are untried, then this amendment request will be treated in the same manner as a new application for use and go before the Radiation Protection Council for consideration.

2.1.10 Review and Updating of Existing Projects

In addition to the on-going radiation surveillance activities in the various laboratories, a conference will be held at least every three years between the Radiation Protection Officer and the Authorized User in Charge of each project to review and evaluate the work being performed to insure that the statements and conditions as specified on the approved project application form are still being followed. An assessment will be made during this conference as to whether minor changes which may have occurred in the project work have in effect rendered the project

so altered as to justify the submission of a project amendment request.

2.1.11 Changes to the Nuclear Reactor Facility and Nuclear Reactor Operating Procedures

Permission to operate the reactor in a standard and prescribed manner merely as a means to generate a neutron field of known magnitude is implied in the granting of the facility license by the Nuclear Regulatory Commission. However, consistent with Nuclear Regulatory Commission rules as found in Title 10, Part 50 of the Code of Federal Regulations and the reactor technical specificiations, changes to the reactor and/or the reactor operating procedures are to take place only with the prior approval of the Radiation Protection Council. Any new reactor operating procedures which may be generated must also be approved by the Radiation Protection Council prior to their enactment. It is the responsibility of the Nuclear Operations Administrator to transmit such proposed changes to the Radiation Protection Council for approval.

The reactor technical specifications allow for a degree of flexibility to be exercised as the need arises for making minor changes to the reactor operating procedures and reactor facilities. In this regard, the Nuclear Operations Administrator may, without prior Radiation Protection Council consideration, approve temporary changes to the reactor operating procedures which do not change the original intent of the procedure. In this same regard, certain minor changes to the reactor facility which are not safety significant may be made without prior Radiation Protection Council approval provided such changes have been approved by the Nuclear Operations Administrator and the officially designated internal Department of Nuclear Engineering technical review group. Such temporarily approved procedural and facility changes must be fully documented and subsequently reviewed by the Radiation Protection Council for permanent approval.

Section 2.1.5 of this handbook gives a full discussion of those actions which are necessary to allow utilization of the nuclear reactor in new and previously unreviewed ways.

2.2 Procurement

The Radiation Protection Council has established control procedures associated with the procurement of radioactive materials and/or ionizing radiation producing devices. Such controls are necessary to insure that all the conditions of the various licenses held by the University are met. These controls cover the procurement of such materials from off-campus vendors as well as those which may be produced at the nuclear reactor facility for use elsewhere on campus.

2.2.1 Requirements to be Met

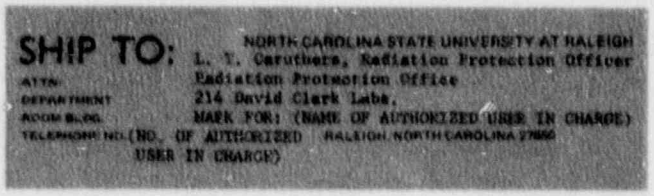
The procurement of all radioactive materials and/or ionizing radiation producing devices in quantities however small is subject to the conditions as specified in this section of the handbook. The proposed user of such materials or equipment in excess of the exemptions listed in Section 2.1.6 of this handbook must have acquired a project number from the Radiation Protection Council prior to ordering such materials. A cooperative arrangement has been established between the Purchasing Department and the Radiation Protection Office to insure that these requirements are met before such materials or equipment are ordered.

The Radiation Protection Officer will make every effort through interaction with the various departments and offices on campus to be aware of the acquisition of any materials or equipment from outside the normal purchasing channel such as through grants or gifts to the University or as equipment or components of equipment delivered as a part of a contracted building modification or equipment installation.

2.2.2 Processing of Purchase Requisitions

a. **Radioactive Materials:** In addition to the information which is normally required by the Purchasing Department, a purchase requisition for the procurement of radioactive material(s) must:

1. have the "SHIP TO" section completed as follows:



2. be sent directly to the Radiation Protection Office where it will be determined if the order falls within the scope of approval of the appropriate radioactive materials project or if it is permitted under Section 2.1.6 of this handbook as an exempt quantity of material. If the material being ordered meets either of these conditions, the purchase requisition will be stamped approved and signed by the Radiation Protection Officer or Associate Radiation Protection Officer. The Purchasing Department will not process purchase requisitions for

radioactive materials which have not been stamped as approved by the Radiation Protection Office. Furthermore, the use of the *NO PURCHASE ORDER* policy using direct payment authorization is not permitted for use in ordering radioactive materials.

3. After approval, the Radiation Protection Office will send the requisition to the Purchasing Department.

b. **Ionizing Radiation Producing Devices:** Purchase requisitions for the acquisition of ionizing radiation producing devices or equipment must be sent to the Radiation Protection Office after preparation. If the device being ordered corresponds to that described in the approved project, the requisition will be stamped approved and signed by the Radiation Protection Officer or the Associate Radiation Protection Officer. After approval, the Radiation Protection Office will send the purchase requisition to the Purchasing Department. It is not necessary to have such devices or equipment shipped directly to the Radiation Protection Office but that office must be notified when the equipment arrives. Furthermore, the equipment must not be installed or used until it has been surveyed by the Radiation Protection Office and until all the safety precautions as specified in the approved project have been instituted.

It will occasionally be necessary to order the components of a large piece of ionizing radiation producing equipment in various phases and over an extended time period; under these circumstances, it is not required that each requisition be routed through the Radiation Protection Office.

2.2.3 Receipt of Radioactive Materials

Upon receipt of the radioactive material shipment, the Radiation Protection Office will measure the radiation level from the package and check to insure that the package is not contaminated. The material will be logged in against the radioactive material inventory for the appropriate project. The material will be delivered to the laboratory and the users will be appraised of any special handling considerations which have been discovered in the process of surveying the shipment. The material must be signed for by one of the authorized project personnel.

2.2.4 Acquisition of Radioactive Materials from the Nuclear Reactor Facility

To the extent that a production mode exists, radioactive materials may be produced in the nuclear reactor facility for use in approved work. The person requesting the production of such material must supply the reactor operations personnel with the approved project number for the use of such material. The user may receive the material directly from the reactor after the reactor personnel have performed the appropriate monitoring checks and determined that the material may be safely handled. The reactor personnel will notify the Radiation Protection Office when the material has been transferred to the user.

2.2.5 Transfer and/or Shipment of Radioactive Materials

As indicated in Section 2.1.6 of this handbook, the transfer of radioactive materials between approved radioactive materials projects is permitted with the approval of the Radiation Protection Officer. The transfer cannot take place until a radioactive material transfer form has been executed. This form must bear the signature of the transferor, the transferee, and the Radiation Protection Officer. The radioactive material to be transferred shall be placed in double containers which are free from surface contamination and shielded when necessary. The Radiation Protection Office may at its discretion survey such containers before the transfer takes place.

Off-campus shipments of radioactive materials may take place only with the approval of the Radiation Protection Officer or other person specifically designated by the Radiation Protection Officer. The shipper of such materials must furnish verification that the consignee has a current license to receive the shipment. The shipper is responsible for packaging such materials in accordance with all applicable state and federal regulations, for the cost of shipping the material, and for delivering the package to the post office or commercial shipping company. The Radiation Protection Office will perform a radiation survey of the package prior to shipment, certify that the package meets all applicable shipping requirements, and delete the material from the appropriate inventory sheet.

2.3 Utilization

The Radiation Protection Council requires adherence to the procedures and regulations listed in this section of the handbook regarding utilization of radioactive materials and/or ionizing radiation producing devices. The procedures and regulations are to be considered as the minimum requirements for insuring radiological safety; additional requirements may be specified for particular uses as the Radiation Protection Council may deem necessary.

2.3.1 Radioactive Materials

Procedures for handling, storage, and disposal of radioactive materials are presented in the following sub-sections.

2.3.1.1 Handling Procedures

Radioactive material handling procedures refer to the use of protective clothing, special manipulative techniques, specialized equipment, and monitoring devices to guard against excessive personnel exposure and the spread of radioactive contamination.

The user is referred to the North Carolina Regulations for Protection Against Radiation, in particular, Part C, Standards for Protection Against Radiation. These regulations establish standards which must be followed in handling radioactive materials, prescribe limits which govern exposure of personnel to radiation, establish allowable concentrations of radioactive material which may exist in the work environment or which may be discharged into the air and water, establish the conditions for disposal of radioactive waste, and establish certain precautionary procedures and administrative controls. Unless otherwise stated in this handbook, users of radioactive materials and/or ionizing radiation producing devices at North Carolina State University are expected to comply with the standards and regulations provided in the North Carolina Regulations for Protection Against Radiation. As future amendments or modifications of these regulations become official, they will also apply to users at North Carolina State University unless more restrictive regulations are provided by the Radiation Protection Council.

Up-to-date copies of the North Carolina Regulations for Protection Against Radiation are available for inspection in the Radiation Protection Office, 214 David Clark Laboratories. If the need arises, copies of these regulations will be distributed to Authorized Users in Charge.

2.3.1.1.1 Contamination Control

Attention is called to the difference between *external* and *internal* hazards from sources of ionizing radiation. Radiation that is external to the body can be readily measured and evaluated. The exposure may be reduced to acceptable values by decreasing the time of exposure, introducing appropriate shielding and/or increasing the distance from the source. The internal radiation hazard is much more subtle and, unfortunately, much more probable in terms of general use of radioactive materials. Limitation of the quantity of material to be used cannot in all cases control internal radiation hazard because the smallest useful quantity may still be extremely hazardous, for example, one microgram of Strontium-90 represents about 100 maximum permissible body burdens. Furthermore, once such radioactive materials become fixed within the body, they are difficult to measure and little can be done to improve the hazard situation. Therefore, meticulous care is required to avoid the deposition of radionuclides within the body by minimizing their entrance. To this end the contamination control procedures listed in this section of the handbook have been established.

2.3.1.1.1.1 Protection of Personnel

a. A primary method of protection of personnel from contamination is through the use of protective clothing. The type of protective clothing and extent to which such protective clothing is required is ultimately defined by the type and level of use of radioactive material. Special protective clothing needs such as the use of coveralls, hoods, shoecovers, and/or respirators will be specified in the approved project or as a direct instruction from the Radiation Protection Officer whenever airborne radioactivity or high level operations are involved. As a minimum, however, gloves and labcoats are required when unsealed sources of radioactive materials are being used and the probability of radioactive contamination is high. Further, rubber or vinyl type gloves shall be worn when handling open vessels containing radioactive materials or when handling any equipment where liquid contamination may be present or where contaminated dust might filter through a cloth glove. These gloves are to be cleaned, if practical, before removal, and all gloves and labcoats are to be stored and handled so as to prevent contamination of the inside surfaces.
b. The pipetting by mouth of liquids containing appreciable radioactivity is forbidden. The term "appreciable" in this connection is taken to include all radioactivity other than naturally occurring trace amounts such as are present in tap water.
c. No work with long-lived alpha and/or beta-gamma emitting radioactive materials in any chemical or physical form is to be conducted by a person having a break in the skin below the elbow.
d. All persons while working with radioactive materials wherein hand and shoe contamination is possible are to:
    1. wash rubber or vinyl gloves before removing from hands unless the radiation level requires immediate removal;
    2. wash hands thoroughly before eating, smoking, or leaving work; and
    3. utilize the available radiation monitoring

equipment to assure that hands and shoes are free of contamination.

2.3.1.1.1.2 Protection of Equipment and Facilities

a. All transfers of materials between hoods and storage areas must be performed so as to avoid the possibility of spillage or breakage. Double containers are recommended in such manipulations.
b. Any work with materials susceptible to atmospheric distribution, i.e., dusting, spillage, vaporizing, effervescence of solution, etc., shall be performed in an adequate hood unless the safety of another procedure has been established.
c. Work areas, trays, glassware, sinks, and other equipment which are subject to become contaminated must be marked with signs, tags, tape, etc. bearing the caution radiation symbol.
d. Loose contamination will not be tolerated on exposed surfaces within the general work area of the laboratory or work space. Whenever such contamination is detected by radiation monitoring procedures, laboratory personnel will clean such surfaces so that removable contamination levels do not exceed *200 dpm per 100 cm² for beta-gamma activity and 20 dpm per 100 cm² for alpha activity*. Radiation Protection Office personnel will provide supervision or assistance in cleaning operations when such cleaning operations become extensive due to widespread contamination. Loose or removable contamination may be unavoidable at times within spaces specifically marked off for radioactive material work such as within a radiochemical fume hood or within special equipment being used in the radiation work. Such contaminated areas or equipment must be kept to a minimum and will be allowed to remain in this contaminated state only for the time necessary to accomplish the work. In other words, such areas or equipment will not be allowed to stay contaminated for long periods of time between uses merely to avoid the effort required for decontamination. Small amounts of fixed contamination may also be unavoidable at times. Maximum limits in this case are *500 dpm above background for alpha activity and one millirem/hour (measured at two cm above the suface) for beta gamma activity*. After determining that the fixed contamination falls below these maximum values, the area should be given one or two coats of a good, hard surface coating. The same standards of contamination control apply to tools and equipment.

2.3.1.1.1.3 Actions to be Taken in Case of a Spill

A spill of radioactive material is considered to be the sudden accidental loss of a significant quantity of such material from its prescribed container, vial, beaker, or chamber to bench surfaces, to the floor, or to the general atmosphere of the laboratory. Such spills are to be reported immediately to the Radiation Protection Office. All spills are to be cleaned up promptly. The responsibility for radiological cleaning rests with the project personnel. Supervision and assistance will be provided by the Radiation Protection Office for spills involving large quantities of material. The Radiation Protection Office may restrict access to the laboratory during cleaning operations. Under extreme circumstances, only Radiation Protection Office personnel may enter such areas for cleaning operations.

2.3.1.1.1.4 Intermixing of Radioactive Work with Non-Radioactive Work

It is recognized that each laboratory cannot afford to purchase all of the equipment commensurate with effective research and that it is necessary to occasionally use certain pieces of specialized research equipment such as spectrophotometers and machine shop devices for both radioactive work and non-radioactive work. This intermixing is allowed for small quantities of radioactive material provided that the person desiring to use such equipment informs the users of the equipment involved in non-radioactive work and the Radiation Protection Office. The Radiation Protection Officer may specify safety precautions in addition to the standard safe handling procedures to guard against the spread of contamination in an uncontrolled area. Temporary caution signs and labels may be specified. The Radiation Protection Office will perform a survey after each use to insure that the equipment or work space has not become contaminated. The allowable limits for contamination in this case will be in conformity with those specified in the following section of this handbook.

2.3.1.1.1.5 Decomissioning of Laboratory or Work Space

When a radioactive materials project is completed, the laboratory or work space shall not be used for non-radioactive work until it has been thoroughly checked and cleared by the Radiation Protection Office. The allowable limits for contamination for decommissioning a laboratory are:

a. Loose contamination detectable by smears:
   1. Alpha Activity—none above minimum detectable activity
   2. Beta-Gamma Activity—none above minimum detectable activity
b. Fixed total contamination as detectable with a portable gas flow proportional counter:
   1. Alpha Activity—100 dpm above background
   2. Beta-Gamma Activity—200 dpm above background

The limits specified above are also applicable to the

circumstance where it becomes desirable to establish a "clean area" within a larger area where radioactive materials are being used, examples of such areas are low level counting rooms and photographic dark rooms. These limits must also be met when tools or equipment are removed from a controlled area to be used in an uncontrolled area.

2.3.1.1.2 Radiation Monitoring Equipment

The Radiation Protection Office shall maintain radiation monitoring equipment of appropriate type and sensitivity to insure that radiation and contamination levels remain below specified values both within the various laboratories using radioactive materials and/or ionizing radiation producing devices and in the environs of North Carolina State University.

Depending on the type of work to be performed, the Radiation Protection Council may specify that the Authorized User in Charge acquire radiation detection equipment for use in the laboratory. This equipment will in most cases consist of portable or bench type radiation survey meters capable of detecting the type of radiation in use. Examples of uses where such equipment will be required are:

a. nuclear reactor applications,
b. large sealed sources which can readily be removed from the shielding material,
c. accelerators or x-ray machines which are capable of generating significant exposure rates, and
d. unsealed source applications where continuous monitoring must be used as a contamination control procedure.

The Radiation Protection Office will assist users in the selection of survey equipment by providing information on the design and availability of such equipment. All such survey instruments will be routinely checked and calibrated by the Radiation Protection Office.

2.3.1.1.3 Limitation on Eating and Smoking

Eating or drinking, storage, or preparation of food in a laboratory or room where radioactive materials are handled is not permitted. Smoking in areas designated for use of radioactive materials is also prohibited. This is in recognition of the inhalation hazard and is consistent with good general laboratory safety.

2.3.1.1.4 Policy on Not Working Alone

Work with radioactive materials in amounts that exceed the values given in Appendix B, Part C of the North Carolina Regulations for Protection Against Radiation shall not be performed by a person working alone. If the experiment does not of itself require two or more people for its execution, then work may be done by one person provided another person, who has a reasonable knowledge of the work, is available in the immediate vicinity to render aid if need arises.

2.3.1.2 Storage of Radioactive Materials

All areas where radioactive materials and/or contaminated equipment are to be stored must be clearly marked with the appropriate warning signs or labels and information pertinent to the stored material including the radioactive element(s), quantity, half-life, radiation level at surface, date of storage, and exact location. Such markings shall be placed so that there will be no radiological risk or hazard to any personnel while reading the information.

Quantities of long-lived alpha emitters or similar hazardous substances having an activity greater than one microcurie shall be securely covered during storage and kept in an adequately protected and ventilated location.

2.3.1.3 Log of Use and Inventory

The Radiation Protection Council requires that the Authorized User in Charge of each radioactive materials project maintain an accurate and up-to-date log-of-use of each such radioactive material used. This log-of-use should be so designed that the quantity of each radioactive material may be specified at any given time as to the fraction of material that is tied up in the various phases of the work, i.e., in storage, in samples, in waste, etc. Based on the log-of-use data, the Authorized User in Charge will supply the Radiation Protection Office with an accurate radioactive materials inventory each calendar quarter so that compliance with the University's Radioactive Materials Licenses may be assured. It is also the responsibility of the Authorized User in Charge to maintain records on the loss of radioactive materials by natural decay and to show the depletion of such materials by this mode on the inventory form.

2.3.1.4 Waste Disposal

All radioactive waste will be collected by the Radiation Protection Office for disposal. Such disposal will consist of hold-up for decay, shipment off-campus for burial, local burial, and under very special conditions the discharging of the material into the sanitary sewer system. The Radiation Protection Office will provide containers for all normal-form liquid and solid wastes. The responsibilities of project personnel regarding waste disposal are listed below:

a. **General Requirements**—Radioactive waste disposal is an expensive service; therefore, experimental practices should be planned so as to minimize the volume of waste. Where appropriate

and beneficial, the user will be provided with sufficient waste containers so that waste may be segregated according to half-life. This will allow the use of natural radioactive decay as a waste disposal technique where short-lived materials are being used. Prior to being picked up by the Radiation Protection Office, all waste containers must be labelled as to radioisotopic content, estimated quantity of each radioisotope and the date. A request for a waste pickup will under normal circumstances take place when the various containers become full; however, a pickup must be requested when the contents of any container causes the dose rate at the surface of that container to reach five millirems per hour. A request for a waste pickup is made by calling the Radiation Protection Office at Extension 2894. The user will give the following information when the waste pickup request is made:

1. name of Authorized User in Charge,
2. room number of laboratory where waste containers are to be picked up,
3. radioactive materials project number,
4. type of waste and number of containers,
5. radioisotopes in waste and estimated quantity of each radioisotope.

The Authorized User in Charge is responsible to inform the Radiation Protection Office personnel of any special hazards to which they may be subjected in the handling of the waste material.

b. **Liquid Waste**—All liquid waste other than those special-form wastes which are highly corrosive, highly reactive, highly flammable, or highly volatile shall be placed in the special container(s) provided by the Radiation Protection Office for this purpose. Special-form wastes will be handled on a case-by-case basis with containers being chosen which will not be degraded by the waste material to be contained. Provisions shall be made for the storage of volatile wastes in a well ventilated location. A fume hood, with the blower operating continuously, serves this purpose.

It is recognized that minute quantities of radioactive liquid waste may be lost to the sanitary sewer system as laboratory cleaning operations take place. This type of loss is considered to be unavoidable and due to the large volume of water that is used each day on the campus, the concentration of radioactive material in such waste in the campus sanitary sewer outfall is inconsequential when compared to permissible levels for release. However, to keep this type of loss to a minimum, disposable containers, vials, syringes, etc. will be used where practical and where glassware and/or equipment must be cleaned for reuse, all but the very final cleaning solution must be collected as liquid waste. Any accidental loss of significant quantities of radioactive materials to the sanitary sewer system will be reported immediately to the Radiation Protection Office.

c. **Solid Waste**—All solid radioactive waste shall be placed into the special containers provided by the Radiation Protection Office for this purpose. Solid waste shall consist of such items as contaminated labware, disposable protective clothing, and paper or plastic materials which were used to protect equipment and bench surfaces from contamination. Special care must be taken to insure that fire hazards and the resultant airborne radioactivity risk are not created by the storage of highly combustible waste material. In such cases special metallic containers will be required.

d. **Biological Waste**—The Radiation Protection Office maintains a burial ground on North Carolina State University property as a means of disposal of radioactive biological waste generated on the campus. Biological waste is considered to consist of animal tissues and/or carcasses, animal excreta, and plant tissues. Freezers are maintained by the Radiation Protection Office to allow for the pickup of biological waste materials as they are generated rather than storing the material in the various laboratories prior to the scheduled burials. If work is planned where large volumes of biological wastes are to be generated including the sacrificing of large animals, this work must be coordinated with the Radiation Protection Office so that the equipment necessary for the burial operation may be scheduled.

e. **Airborne Waste**—All operations with radioactive material where it is known that significant quantities of gaseous or airborne particulate radioactive materials may be lost will be conducted in a high quality radiochemical fume hood. Further, such releases will also be controlled by the use of traps, filters, or other experimental techniques. The loss of very small quantities of airborne radioactive material via a fume hood exhaust system which results merely as an air contamination problem rather than as a planned release is at times unavoidable. However, the concentration of radioactive material in the hood exhaust must at *all* times be in conformity with the limits specified in Section 2.1.8.1.2 of this handbook. The quantity of radioactive material released in this fashion must be determined accurately and recorded as a waste loss on the radioactive materials inventory form.

2.3.1.5 Policy on Off-Campus Use

No radioactive source with activity greater than

one microcurie may be taken off campus other than as expressly approved by the Radiation Protection Council or its representative.

2.3.2 Ionizing Radiation Producing Devices

The procedures for utilization of ionizing radiation producing devices are designed to control the external radiation exposure hazards which arise from the use of such equipment. This use must be in conformity with all the applicable requirements of the North Carolina Regulations for Protection Against Radiation and Section 3 of this handbook. The safety precautions are most likely to vary considerably with each device to be used since conditions of use and machine location will tend to make each use unique. For this reason the Radiation Protection Council requires strict adherence to the provisions of the approved project for the use of such equipment. This will include the use of shielding material, safety interlocks, specialized operating procedures, etc. as specified in the approved project. Training of personnel in the proper radiological safety procedures is also most important for the use of such devices; the Authorized User in Charge of this work must insure that such training takes place.

2.3.3 Nuclear Reactor

The actual manipulation of the nuclear reactor takes place only by operators who are licensed by the Nuclear Regulatory Commission. These specialized personnel operate the reactor only by prescribed, written procedures. Access to and utilization of the auxiliary equipment associated with the reactor such as remote sample loading devices is permitted for personnel who meet all the appropriate approved project and training requirements. This access is also controlled by procedures written specifically to accommodate the special radiation and contamination hazards associated with the use of the reactor. These procedures are written and maintained by the Reactor Health Physicist. These procedures must meet all the applicable requirements of Title 10 of the Code of Federal Regulations, the North Carolina Regulations for Protection Against Radiation, and this handbook; and they may be more restrictive as deemed necessary by the Reactor Health Physicist.

SECTION 3 PERSONNEL EXPOSURE CONTROL

3.1 External Radiation Exposure

This section of the handbook discusses those measures both regulatory and procedural which have been established to minimize external radiation exposure. External radiation exposure refers to the exposure of personnel to ionizing radiation which originates from sources external to the body. Such exposure may refer to the irradiation of the whole body or any portion thereof.

3.1.1. Exposure Limits

Experiments or work involving the use of radioactive materials and/or ionizing radiation producing devices shall be designed to meet the goal stated in the introduction to this handbook of insuring that radiation exposure shall be no greater than that which is warranted when the benefits from the use and the associated risk are properly balanced. Under no circumstances, however, will exposures exceed the limits specified in the following subsections of this handbook.

3.1.1.1 Maximum Permissible Exposure Limits

As a requirement of the various licenses which are held by the University, no use of radioactive materials or ionizing radiation producing devices shall be conducted which can result in personnel exposures which will exceed the values stipulated in the North Carolina Regulations for Protection Against Radiation, Section C.101, and/or the Code of Federal Regulations, Title 10, Part 20. In this regard, the North Carolina and federal regulations are compatible and they state that:

a. except as provided in Paragraph b. below, no licensee or registrant shall possess, use, receive or transfer sources of radiation in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from all sources of radiation in the licensee's or registrant's possession a dose in excess of the amounts specified in the following table:

PART OF BODY	REMS PER CALENDAR QUARTER
1. Whole body, head and trunk, active blood forming organs, lens of the eyes, or gonads	1.25
2. Hands and forearms, feet and ankles	18.75
3. Skin of whole body	7.5

b. A licensee or registrant may permit an individual in a restricted area to receive a dose to the whole body greater than that permitted under Paragraph a. above, provided that

1. during any calendar quarter the dose to the whole body from sources of radiation in the licensee's or registrant's possession shall not exceed three rems;

2. the dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5(n - 18) rems where "n" equals the individual's age in years at his last birthday; and

3. the licensee or registrant has determined the individual's accumulated dose to the whole body on State of North Carolina Form RAD H-102 or Nuclear Regulatory Commission Form NRC-4, whichever is appropriate.

The above is a current statement of the state and federal exposure control regulations; any future amendments of these regulations shall supersede and take precedence over the limits stated above.

3.1.1.2 North Carolina State University Exposure Limit

The Radiation Protection Council has established a whole body radiation exposure limit which is more restrictive than that permitted by state and federal regulations. Under this Radiation Protection Council limit, individual exposures are limited to *1.25 rems/calendar quarter total exposure and at the same time no more than 100 millirems may be received in any given week of that quarter.* For purposes of defining this limit, a week is considered to be any period of seven consecutive days.

The Radiation Protection Council has directed the Radiation Protection Officer to conduct an investigation of all exposures which exceed this limit and to submit a formal report to the Radiation Protection Council on the finding of this investigation and the measures taken to prevent reoccurrence. A copy of this report shall be attached to the permanent personnel monitoring record of the individual

When the work to be performed justifies higher exposures, written permission must be obtained from the Radiation Protection Officer to exceed the weekly maximum permissible exposure. Under no circumstances will work be planned that could result in exposures in excess of the limits specified in Section 3.1.1.1 of this handbook.

3.1.1.3 Policy on the Limitation of Exposure of Minors

Persons under 18 years of age may not work in areas where radioactive materials and/or ionizing radiation producing devices are used except by special permission from the Radiation Protection Council. When such permission is granted, the weekly exposure for such persons shall not exceed ten percent of the 100 millirems/week maximum permissible exposure limit. Persons working under these circumstances must be equipped with direct reading personnel dosimeters in addition to those personnel monitoring devices described in Section 3.1.2.1 of this handbook.

3.1.1.4 Policy on the Limitation of Exposure of Visitors

The term "visitors" is used to designate all persons for whom personnel monitoring service is not provided on a routine basis. Since the previous exposure history of such persons has not been obtained and documented, the exposure of such persons will be limited to 25 percent of the maximum permissible weekly exposure (25 millirems/week). Visitors will be provided with direct reading dosimeters, where applicable, in addition to the regular personnel monitoring device prescribed for the area being visited.

3.1.1.5 Policy on the Limitation of Exposure of the General Public

For purposes of this discussion, the general public is considered to be all those individuals, including the general population of North Carolina State University, who may be in the vicinity of ionizing radiation sources being used on the University campus. The Radiation Protection Council requires that every reasonable effort be made to reduce exposures in this category of individuals to an absolute minimum. To insure that this condition is met:

a. **no project personnel shall possess, use, or transfer any radioactive materials or ionizing radiation producing devices in such a manner as to create in any unrestricted area from such sources of radiation:**
   1. **radiation levels which, if an individual were continuously present in the area, could result in this individual receiving a dose in excess of two millirems in any** *one hour*, **or**
   2. **radiation levels which, if an individual were continuously present in the area, could result in this individual receiving a dose in excess of 100 millirems in any** *seven consecutive days*; **and furthermore,**
b. **no project personnel shall possess, use, or transfer any radioactive materials or ionizing radiation producing devices in such a manner as is likely to cause any individual who is intermittently or continuously exposed in any unrestricted area to receive a dose in any** *calendar year* **in excess of 500 millirems.**

3.1.2 Exposure Control Procedures

The procedures used to minimize external radiation exposure for the most part will consist of applying the very basic but effective concepts of distance, time, and shielding protection. The applicant for a proposed use of radioactive materials or ionizing radiation producing devices shall provide an analysis of the external radiation hazards on the project application (Form RPO-1). Based on this analysis, the applicant will further describe any shielding material and special handling devices which are to be used to reduce radiation to acceptable levels. In this connection, it will occasionally be necessary to employ the use of sophisticated devices such as specially designed shielding apparatus, remote manipulators and/or remote pipettors. Barricades and warning markers will be established so as to properly inform persons of the storage areas and places of use to insure that persons remain at a safe distance from such sources (the criteria for posting such warning markers is presented in Section 2.1.8.1 of this handbook).

3.1.2.1 Personnel Monitoring Program

The Radiation Protection Office conducts a program of personnel radiation monitoring which consists of: (i) the issuance of personnel monitoring devices, (ii) the periodic collection of such devices for analysis, (iii) the maintenance of official records of personnel exposure as assessed from the monitoring devices, and (iv) the supplying of official reports of such exposure to the exposed persons and other agencies when appropriate. A whole body personnel dosimetry device will be issued to any user who shall be subject to penetrating whole body radiation which is likely to result in an exposure of as much as 25 percent of the maximum weekly exposure (25 millirems/week) or whenever it is deemed necessary by the Radiation Protection Officer. Under some circumstances users will be issued extremities monitoring devices such as a wrist or ring type dosimeter and where needed direct reading dosimeters will be issued.

The Authorized User in Charge is responsible to see that application is made to the Radiation Protection Office for personnel monitoring service for all project personnel. This is accomplished by submitting Form RPO-2 entitled "Personnel Monitoring Service" (available in the Radiation Protection Office) for each individual. The form must be completely filled out and signed by the Authorized User in Charge. The Radiation Protection Office must also be informed when persons are no longer subject to exposure and should therefore be dropped from the list of persons receiving monitoring service; this reporting requirement is also the responsibility of the Authorized User in Charge.

Internal dosimetry results are also included as part of a user's official personnel monitoring record (internal dosimetry is discussed in Sections 3.2.2 and 3.2.3 of this handbook).

3.1.2.1.1 Responsibilities of Individual Receiving Personnel Monitoring Service

It is the responsibility of each individual who has been issued a personnel monitoring device to wear this device during all times when he is subject to exposure to ionizing radiation. Further, such devices are to be stored in a location as designated by the Authorized User in Charge and/or the Radiation Protection Office when not in use. This includes off-duty hours which means that the monitoring devices

are not to be taken home. Personnel monitoring devices are not to be tampered with in any way. If such devices are lost or if they appear to have been damaged, this must be reported immediately to the Authorized User in Charge and the Radiation Protection Office and no work is to be performed until a replacement dosimeter device has been issued. Under no circumstances shall an individual use a personnel monitoring device which has been issued to another person. Personnel monitoring devices are not to be worn during exposure to any medical use of ionizing radiation.

3.1.2.1.2 Collection of Personnel Monitoring Devices for Assessment of Accumulated Dose

Personnel monitoring devices will be collected periodically for assessment of accumulated dose. This collection process and frequency is as follows:

a. **Permanent Employees**—Personnel monitoring devices which have been issued to permanent faculty and staff members will be collected monthly and a new monitoring device will automatically be issued.
b. **Graduate Students and Temporary Employees**—Personnel monitoring devices which have been issued to graduate students who are involved in a research program which is expected to last several months or to temporary employees will be collected monthly and a new monitoring device will automatically be issued.
c. **Students in Laboratory Sessions**—Personnel monitoring devices which have been issued to students in laboratory sessions will be collected at the end of the semester or after 13 weeks whichever is the shorter period. Monitoring devices will not automatically be re-issued in this case but at such time as a new need arises.
d. **Visitors**—Visitors will be issued the same personnel monitoring devices as has been established as standard for the area being visited. The personnel monitoring devices will be collected and processed at the end of the visit. The Authorized User in Charge is responsible for the safety of persons visiting the radiation work area.

3.1.2.2 Medical Examinations

a. **Blood Counts**—A complete blood count shall be performed for each staff member who will be working with ionizing radiation of such magnitude that the radiation dose to such staff members is likely to approach the maximum permissible limit. This examination will take place prior to the work with ionizing radiation and again each two years thereafter until such work is terminated. These blood counts will be scheduled by the Radiation Protection Office and the results will be maintained in the individual's permanent personnel monitoring file.
b. **Eye Examinations**—Where work involves significant exposure to neutrons, a careful ophthalmic examination shall be conducted every two years. These examinations shall be scheduled by the Radiation Protection Office and the results will be maintained in the individual's permanent personnel monitoring file.

3.2 Internal Radiation Exposure

Internal radiation exposure refers to the exposure of personnel to ionizing radiation that originates from radioactive material which has become deposited in the body either by ingestion or inhalation. Control of internal radiation exposure is quite logically effected through minimization of the intake of radioactive material into the body. Section 2.3.1.1.1 of this handbook lists in detail the measures to be taken to control contamination which in turn reduces the possibility of internal deposition. The statements which follow in this section of the handbook refer to the regulatory limits on concentration of radioactive material in the air and water and describe the actions to be taken, where appropriate, to measure internal radiation dose.

3.2.1 Maximum Permissible Concentration of Radioactive Material in Air and Water

Every reasonable effort shall be made in the planning and execution of experiments using radioactive materials to eliminate the generation of airborne or waterborne radioactive material through the use of the various handling procedures previously discussed in Section 2.3.1.1 of this handbook. Under no circumstances, however, will radioactive materials be used in such a way as to generate concentrations of radioactive material in air or water in excess of the limits specified in Appendix A to Part C of the North Carolina Regulations for Protection Against Radiation. Maximum permissible concentrations are listed therein for the various radionuclides in air and water for both restricted areas and general public situations.

3.2.2 Bioassays

Where conditions warrant, bioassay procedures shall be used to determine the extent of internal exposure. Such procedures consist of counting biological eliminations for specific radionuclide content and then calculating the internal dose. The Radiation Protection Officer in consultation with the Authorized User in Charge will designate the person-

nel, the type of examination, and the frequency of examinations. The bioassay procedure will be conducted by the Radiation Protection Office and the results will be maintained in the appropriate personnel monitoring file.

3.2.3 Whole Body Counts and Internal Organ Scans

Where levels of radioactive material are being used which warrant concern and where bioassay procedures cannot be used, persons so exposed will be subjected to whole body or specific organ counting examinations. Such procedures will be performed by the Radiation Protection Office and/or contracted for at an appropriate medical facility.

RPO-1/77

APPENDIX A

NORTH CAROLINA STATE UNIVERSITY AT RALEIGH
APPLICATION FOR PERMISSION TO OBTAIN AND/OR UTILIZE MATERIALS OR DEVICES WHICH EMIT IONIZING RADIATION

(Submit original plus four copies)

FOR USE BY RADIATION PROTECTION COUNCIL ONLY

PROJECT NO. _____

CONDITIONS OF APPROVAL

YES_____ NO_____

SECTION 1

TO BE USED IN

DEPARTMENT _____ BUILDING AND ROOM _____

TITLE OF WORK _____

SECTION 2

PROJECT PERSONNEL

2.1 Authorized User in Charge _____

• Campus Address _____ Phone: Work _____ Home _____

2.2 Personnel Data (Include Authorized User in Charge)

Name	Age	Accumulated Dose

2.3 Experience of Authorized User in Charge
(Describe previous work; include approximate dates)

• Have you been refused the use of radioactive materials or ionizing radiation producing equipment by any other agency or institutions? Yes_____ No_____

SECTION 3

DESCRIPTION OF MATERIALS OR DEVICES TO BE USED

(Complete Appropriate Items)

3.1 Radioactive Material(s)

3.1.1

Kind	Millicuries	Radiations	Energy	T½	Physical State	Chemical Form

3.1.2 Is radioactive material to be produced at the Nuclear Reactor Facility? Yes____ No____ (If yes, refer to Section 3.3)

3.1.3 External Hazard Evaluation

- Millirem/hour at 1 meter:
- Shielding required for 2.5 millirem/hour at working distance:
- Shielding to be used:
- Radiation level expected in storage place:

3.1.4 Internal Hazard Evaluation

- Critical Organ:
- Maximum permissible body burden:
- Effective half-life:
- $\frac{\text{Activity requested}}{\text{Maximum permissible body burden}} =$
- $\frac{\text{Aliquots to be used}}{\text{Maximum permissible body burden}} =$

3.1.5 Description of Use

Provide a description of the use of the radioactive material(s) which will include but not be limited to the information on Form RPO-1(S) entitled "Supplemental Information Required for the Use of Radioactive Materials" (Use additional sheets if necessary)

3.2 Ionizing Radiation Producing Devices

3.2.1 X-Ray Machine (Include devices which produce X-rays as a by-product, such as plasma units)

- Type: ☐ diffraction ☐ diagnostic ☐ therapeutic ☐ other, describe

_____

- Operating characteristics: Voltage _____ Current _____
- Describe safety interlocks _____

_____

- Describe location of machine (include special design features) _____

_____

- List monitoring equipment to be used _____
- Attach copies of manufacturer's operating and safety instructions

3.2.2 Accelerator

- Type _____
- Operating characteristics: Voltage _____ Max. beam current _____
- Nucleons to be accelerated _____
- Target materials to be used (if radioactive target materials are used, then Section 3.1 must be completed)

_____

- Radiation emitted by target material _____
- Radiation emitted from structural components of machine or shielding material _____

_____

- List monitoring equipment to be used _____
- Attach operating instructions and describe safety features such as interlocks _____

_____

_____

- Attach a diagram of the location of the accelerator (specify special design features such as shielding, etc.) _____

_____

3.3 Nuclear Reactor

The NCSU Radiation Protection Handbook lists the responsibilities of the user with respect to the receipt of samples which have been irradiated in the nuclear reactor. Section 3.1 of this form must be completed if such samples are irradiated for the production of radioactive materials. If you propose a use for the nuclear reactor which is new and untried, information must be supplied as prescribed in the Nuclear Regulatory Commission approved license documents. Consultation with the Radiation Protection and/or the Reactor staffs will be necessary in this case to further define these requirements.

SECTION 4
AFFIRMATION AND APPROVALS

I affirm that the foregoing facts are correct to the best of my knowledge and that I shall conduct and/or supervise the described work with full regard for the safety of those engaged in the work and of the general public. I understand that the statements which I have made in this application, along with any conditions of approval which may be added by the Radiation Protection Council, shall serve as the official basis for performing this work. I have received and read a copy of the North Carolina State University Handbook for Protection Against Ionizing Radiation and understand that I am to abide by the policy contained therein.

Signed _____ , Applicant Date _____

I have personally reviewed this application with the applicant, have examined the laboratory in which this work is to be performed, (have - have not) observed a "cold" run and recommend that approval be (granted - denied) provided that any recommendations listed below are followed.

Recommendations:

Signed _____ , Radiation Protection Officer Date _____

The Radiation Protection Council (grants - denies) permission to obtain and use the requested materials and/or devices in the manner described in this application and any conditions of approval listed below.

Conditions of approval:

Signed _____ , Chairman Date _____

APPENDIX B

SUPPLEMENTAL INFORMATION REQUIRED ALONG WITH APPLICATION FOR PERMISSION TO OBTAIN AND USE RADIOACTIVE MATERIALS

When applying for permission to obtain and use radioactive materials, the following information should be furnished. Submit original and four copies.

1. *Description of Work*

Provide a brief description of the experiment which demonstrates the extent to which radioactive materials are involved in each phase of the experiment. Sufficient detail should be provided so that an assessment of the radiation hazards that may arise during the flow of the experiment may be made. A typical example of this would be the case where one starts out with a labeled solution and then by experimental manipulation a radioactive gas is evolved. (The following items on this form provide a convenient format for indicating the protective measures which will be instituted to minimize such potential radiation hazards.)

2. *Work Areas*

List the laboratories, greenhouses, field facilities, or other areas where work involving the radioactive material will be performed. Comment on the equipment, facilities and general condition of the work areas to the extent that a judgment may be made as to whether the radiation work may involve or interact with other work being performed in the area.

3. *Storage Areas*

Specify where, in what amounts, and in what form the radioactive materials are to be stored.

4. *Manipulations with the Radioactive Materials*

a) Tracer Uses—If a stock solution containing a radioisotope is to be diluted or separated into aliquots, this process should be described giving the method of dilution; and the facility where this is to be accomplished; e.g., in a hood, glove box, etc. Specify how such aliquots are to be identified and labeled. Subsequent labeling procedures should be described indicating (i) what is to be labeled; (ii) how this is to be accomplished; (iii) where it is to be stored; and (iv) assay procedures to be used if applicable.

b) Sealed Sources—Provide a detailed description of the source including chemical form, physical dimensions, method of encapsulation, thickness of encapsulation, etc. A description of how the source is to be secured, shielded, and the dose rate expected in the general area of use must also be provided.

5. *Handling Procedures*

Handling procedures such as use of gloves, lab coats, tongs, marking tape, absorbent paper, etc. should be specified.

6. *Radiation Surveys*

Where applicable, describe those radiation survey instruments which are available to be used for checking experimental apparatus, work surfaces, and personnel during experiment.

7. *Duration of Experiment*

An estimate as to duration of the total experiment and time involved in particular phases should be made, such as, time involved from tagging animals to subsequent sacrifice or the time a sealed source would be used in a specific location.

8. *Waste Disposal*

All radioactive waste such as unused solutions, biological waste, contaminated paper, etc. is to be turned over to the Radiation Protection Office for disposal. In connection with this, provide an estimate of the amounts, form and bulk of waste. Describe any particular hazards associated with the handling of the waste materials, e.g. are highly corrosive materials involved.

APPENDIX C

The following is a partial list of publications on regulations, standards, and principles of radiation protection. Users should become familiar with the contents of these documents as they apply to their specific work.

a. Standards for Protection Against Radiation, Code of Federal Regulations, Title 10, Part 20.
b. North Carolina Regulations for Protection Against Radiation, North Carolina Statutes—G.S. 104C.
c. Reports of the National Council on Radiation Protection (NCRP Publications, P.O. Box 30175, Washington, D.C. 20014).
   - No. 8 — Control and Removal of Radioactive Contamination in Laboratories.
   - No. 10 — Radiological Monitoring Methods and Instruments.
   - No. 22 — Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure.
   - No. 23 — Measurement of Neutron Flux and Spectra for Physical and Biological Applications.
   - No. 25 — Measurement of Absorbed Dose of Neutrons and of Mixtures of Neutrons and Gamma Rays.
   - No. 28 — A Manual of Radioactivity Procedures.
   - No. 30 — Safe Handling of Radioactive Materials.
   - No. 32 — Radiation Protection in Educational Institutions.
   - No. 33 — Medical X-Ray and Gamma-Ray Protection for Energies up to 10 MeV—Equipment Design and Use.
   - No. 36 — Radiation Protection in Veterinary Medicine.
   - No. 38 — Protection Against Neutron Radiation.
   - No. 39 — Basic Radiation Protection Criteria.
   - No. 43 — Review of the Current State of Radiation Protection Philosophy.
   - No. 46 — Alpha-Emitting Particles in Lungs.
   - No. 47 — Tritium Measurement Techniques.
   - No. 48 — Radiation Protection for Medical and Allied Health Personnel.
   - No. 49 — Structural Shielding Design and Evaluation for Medical Use of X-Rays and Gamma-Rays of Energies Up To 10 MeV.
     - — Adjunct to NCRP Report No. 49 (Full-sized reproductions of barrier requirement curves).
   - No. 50 — Environmental Radiation Measurements.
   - No. 51 — Radiation Protection Design Guidelines for 0.1-100 MeV Particle Accelerator Facilities.

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