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1/2017	1	Remove Gamma Irradiator reference RSO-5 form	RSC
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1/2017	3	Change references from EHS to RSO	RSC
4/2019	4	Edit section 5.4 to remove shipping building	RSO

RADIATION SAFETY PLAN

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Section 1:Introduction

Radiation may be defined as energy traveling through space. All forms of ionizing radiation have sufficient energy to ionize atoms that may destabilize molecules within cells and lead to tissue damage. Non-ionizing radiation is essential to life, but there can be tissue damage with excessive exposure.

Radiation sources are found in a wide range of occupational settings and the goal of NSU's radiation safety plan is to protect the user, co-workers and the general public from exposure to excessive levels of radiation and concentrations of radioactive materials. The regulations and procedures outlined in this Plan are intended to protect all individuals with a minimum of interference in their activities and are consistent with regulation of the U.S Nuclear Regulatory Commission (NRC), the Florida Department of Health (DOH) and OSHA.

The Federal and State regulations for ionizing and non-ionizing radiation are:

Code of Federal Regulations

- Title10: Energy CFR Part 20 "Standards for protection against radiation"
- Title10: Energy CFR Part 19 "Notices, instructions and reports to workers: inspection and investigations"
- Title 10: Energy CFR Part 21 "Reporting of defects and noncompliance"
- Title 29: Labor CFR 1910 Occupational Safety and Health Standards - Subpart Z 'Toxic and Hazardous Substances"; 1910.1096 "Ionizing radiation"

State of Florida, Department of Health

- Chapter 64E-5, F.A.C., Control of Ionizing Radiation Hazards
- Chapter 64E-4, F.A.C., Control of Non-ionizing Radiation (Laser) Hazards
- Chapter 64E-3, F.A.C., Radiologic Technology

In 1964, the Atomic Energy Commission (now the U.S. Nuclear Regulatory Commission) and Florida signed an agreement empowering the state to license and regulate radioactive materials users. The license is a dynamic document. See Appendix A for the copy of the State of Florida's license application. The State of Florida's Radiation program issues over 1,600 license amendments annually to accommodate the licensees' and industry's changing needs. Each materials license is valid for 5 years.

Program staff inspects each licensee periodically from every 6 months to every 5 years depending on the type of license. During the inspection, which may take 100 hours or more at a large facility, the inspector takes direct radiation readings and interviews and observes personnel. The inspector also reviews records, and if necessary, collects samples from equipment surfaces and the general environment which are later analyzed for contamination at the department's radiation laboratory.

The inspector then discusses the preliminary inspection findings with the licensee during an exit interview and, within 30 days of the inspection, program staff sends a letter requiring corrective action of any deficiencies. If the licensee has significant violations or fails to correct the

deficiencies, the department may impose an administrative fine or modify, suspend, or revoke the license.

1.1 Objective

The primary objectives related to protection from radiation hazards are divided into two general categories: (1) those intended to protect personnel from immediately observable deleterious effects after an exposure and (2) those intended to prevent latent injuries or conditions that may occur from much lower levels or repeated exposures.

Radiation is defined as energy in transit in the form of high speed particles and electromagnetic waves. It can be broadly classified as ionizing radiation and non-ionizing radiation.

1. Ionizing Radiation

There are two types of ionizing radiation: particulate (alpha, beta, neutrons) and electromagnetic (x-rays, gamma rays).

The protection objectives related to this type of hazard are aptly stated in the National Council on Radiation Protection and Measurements, Report No. 116, Limitation of Exposure to Ionizing Radiation. The report states that "The specific objectives of radiation protection are:

a) To prevent the occurrence of clinically significant radiation induced deterministic (non-stochastic) effects by adhering to dose limits that are below the apparent threshold levels.

b) To limit the risk of stochastic (probabilistic) effects, cancer and genetic effects, to a reasonable level in relation to societal needs, values, benefits gained and economic factors."

2. Non-Ionizing Radiation

Electromagnetic radiation ranging from extremely low frequency (ELF) to ultraviolet (UV) comprise non-ionizing radiation.

a) Laser Radiation

The primary focus is to prevent thermal injury to the eyes or skin of personnel due to direct or scattered laser beams. Protection from associated non-beam hazards such as fire, electrical, compressed gas, and generated aerosols due to the use of laser devices must also be considered. Potential long-term effects may occur if eyes of exposed individuals are not adequately protected from certain wavelengths of laser beams.

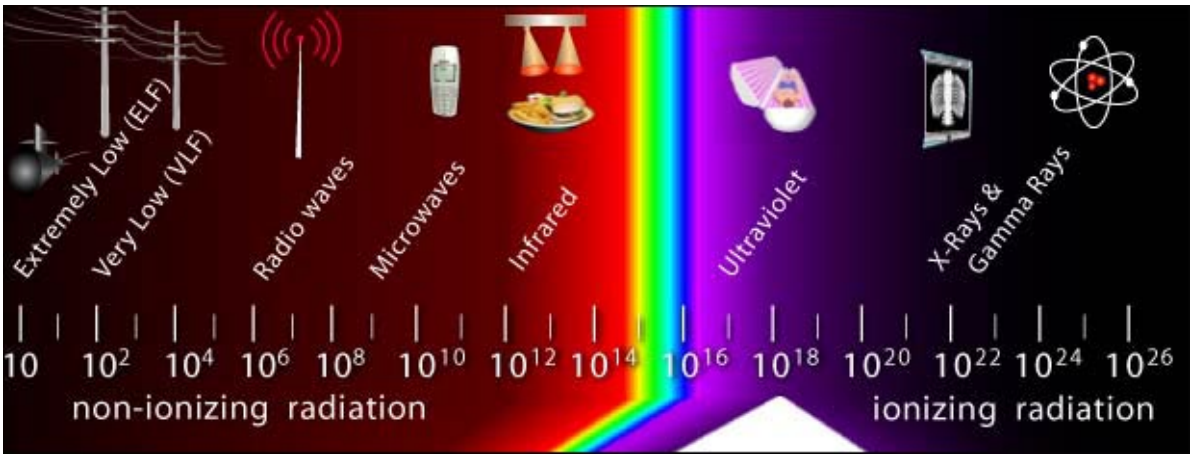
b) UV Radiation

Exposure to ultraviolet radiation (UV-A, UV-B, and UV-C) is generally controlled to prevent thermal injury to the eyes and skin. Potential long-term damage that can lead to cancers or cataracts can also be controlled through engineering controls or the use of personal protective equipment.

c) Magnetic Field, Microwave, and other Electromagnetic Radiations

The potential for harm from these hazards is believed to be limited to those that may occur acutely from the deposition of heat within a person's body. Current standards and regulations are focused entirely on preventing injury from short-term exposures associated with these hazards. Research on long-term effects of these kinds of exposures remains inconclusive.

Illustration 1: Radiation Variations



Source: OSHA

ISO 21482: The "Ionizing Radiation Warning" is depicted with radiating waves, a skull and crossbones and a running person, a new ionizing radiation warning symbol has being introduced to supplement the traditional international symbol for radiation, the three cornered trefoil. It was launched by the International Atomic Energy Agency (IAEA) and the International Organization for Standardization (ISO) to help reduce needless deaths and serious injuries from accidental exposure to large radioactive sources.

The symbol is intended for IAEA Category 1, 2 and 3 sources defined as dangerous sources capable of death or serious injury, including food irradiators, teletherapy machines for cancer treatment and industrial radiography units. The symbol is to be placed on the device housing the source, as a warning not to dismantle the device or to get any closer. It will not be visible under normal use, only if someone attempts to disassemble the device. The symbol will not be located on building access doors, transportation packages or containers.

1.2 ALARA

The NRC has set annual exposure limits for radiation based on the conservative assumption that there is no safe level. In other words, even the smallest exposure has some probability of causing a stochastic / late effect such as cancer or genetic damage. This assumption has led to the general philosophy of not only keeping exposures below recommended levels or regulatory limits, but of also maintaining all exposures "**A**s **L**ow **A**s **R**easonably **A**chievable" (**ALARA**). ALARA limits are the basic requirements for current radiation safety practices which means that every effort must be taken to ensure that the dose to employees and the public are kept below the required limits. The regulatory guideline requires managing programs and procedures to achieve ≤ 10% of

applicable legal limits, such as air and water release limits, exposure limits or contamination limits for radiation use facilities.

The dose of radiation is measured in rem (REM).

TABLE A: ALARA Dose Limits

Body Part	Annual Limit (rem)
Whole Body	5 (5000 mrem)
Skin	50 (50,000 mrem)
Extremity	50
Lens of the Eye	15 (15,000 mrem)
Minors and members of the public	0.1 (100 mrem)

The dose to an embryo or fetus during the entire pregnancy from occupational exposure of a declared pregnant woman shall not exceed 0.5 rem (500 mrem). It is recommended that not more than 0.05 rem be received by the embryo or fetus in any one month.

The NRC and the State of Florida require instructions to occupational workers in the hazards associated with radioactive material and radiation, and in the precautions and safety measures to be followed to minimize exposure (10 CFR 19.12 and 64E - 5.902). Licensees are advised that such instructions must include special instructions to females of childbearing potential, regarding the risks to the unborn fetus associated with prenatal radiation exposure.

1.3 Definitions

Absorbed Dose: the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the rad and the Gray (Gy).

Activity: when talking about radioactive material, the units of Curie or Becquerel (SI unit) or number of nuclear disintegrations per minute (dpm) are used to describe the quantity of material that is present.

Committed Dose Equivalent (CDE): the dose equivalent to organs or tissues of reference that will be received from an intake of radioactive materials by an individual during the 50 year period following the intake.

Committed Effective Dose Equivalent (CEDE): the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues.

Deep Dose Equivalent (DDE): applies to external whole-body exposure, is the dose equivalent at a tissue depth of 1 cm ($1000 mg/cm^2$).

Dose Equivalent: a measure of how much energy is absorbed by the body from radiation. Dose equivalent means the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem

and sievert (Sv). 100 rem = 1 Sv. These are also the units reported on your dosimetry report and quantify how much dose you have received.

Effective Dose equivalent (EDE): the sum of the products of the dose equivalent to the organ or tissue and the weighting factors applicable to each of the body organs or tissues that are irradiated.

Exposure: the term used to describe the amount of ionization produced in air from a radiation source. The unit used for this measurement is Roentgen (R) or milliroentgen (mR). Most portable survey instruments measure exposure. Exposure rate measurements can be used to calculate dose or dose equivalent.

Gray: the SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 Joule/kilogram (100 rads)

Lens Dose Equivalent (LDE): applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter.

Mega Electron Volt (MeV): unit of measurement which quantifies the amount of energy carried by particulate or electromagnetic radiation, e.g. Cs-137 emits a 0.662 MeV gamma ray and P-32 emits a 1.7 MeV Beta particle.
Rad: the special unit of absorbed dose. One rad is equal to an absorbed dose of 100 ergs/gram.

Rem: the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rems is equal to the absorbed dose in rads multiplied by the quality factor (1 rem = 0.01 sievert (Sv))

Shallow Dose Equivalent (SDE): applies to the external exposure of the skin of the whole body or the skin of an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter.

Sievert: the SI unit of any of the quantities expressed as dose equivalent. The dose equivalent in sieverts is equal to the absorbed dose in grays multiplied by the quality factor (1 Sv = 100 rems)

Total Effective Dose Equivalent (TEDE): the sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Total Organ Dose Equivalent (TODE): sum of the CDE and DDE for the maximally exposed organ.

Section 2:Biological Effects and Exposure Protection

2.1 Biological Effects of Radiation

If an organism is given a significantly large dose of ionizing radiation within a relatively short period of time, there will be definite effects due to the irradiation. For example, a dose of several hundred rads delivered rapidly to the whole body of a mammal produces the "acute radiation syndrome" with severe illness or possibly death. Exposures of less than that required to produce the acute radiation syndrome may still produce genetic effects and will affect growth and development, the incident of neoplasms, and the life span.

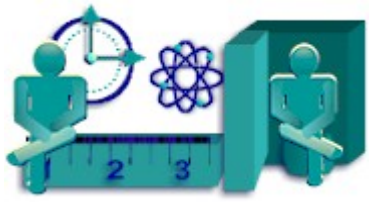
These effects have been observed at doses greatly in excess of those presently recommended by national, state and local radiation protection agencies. At the present acceptable levels of radiation exposure, no cellular changes in mammals can be detected. There is no lower level to the amount of radiation that can produce gene mutations. All these aspects of radiation damage were taken into consideration when the National Council on Radiation Protection and Measurements (NCRP), the unofficial authority on radiation protection, established recommended maximum permissible dose (MPD) values for different segments of the population. The primary objective in establishing MPD values for a person who works with radiation in his occupation is to keep his exposure well below a level at which adverse effects are likely to occur during this lifetime. Another objective is to minimize the incidence of genetic effects for the population as a whole. These dose limits do not include any dose received by an individual as a patient or the dose from natural background radiation.

It must be emphasized that the risk to individuals exposed to an MPD or the dose limits for the population is considered to be very small; however, risk increases with increasing dose. For this reason, it is desirable to keep radiation exposures as low as practicable with due consideration to medical objectives, feasibility, and efficiency of operation. Small deviations in the exposure of an individual above prescribed levels are important if protection practices are inadequate.

2.2 Exposure - External

There are three basic concepts that affect an employee's exposure to ionizing radiation: time, distance and shielding.

Illustration 2: Basic concepts of radiation protection



1. Time

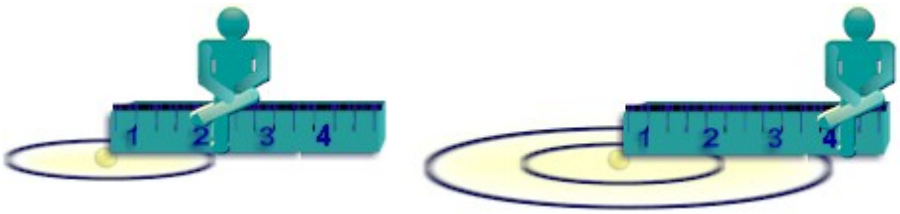
Time is an important factor when considering the amount of exposure of an employee to radioactive material. Depending on the length of time an employee spends near the source of radiation will determine the amount of external radiation exposure. Time should be minimized especially when working with gamma and x-ray materials.

2. Distance

Exposure to radiation will be less the further you are away from the source, and the required distance depends on the energy of the radiation and the activity of the source. The primary radioactive material of concern is gamma rays because the rays can travel long distances. Alpha and beta particles have lower energy and do not travel very far. When working with radioactive material it is important to remember that if you double the distance from the source, you reduce your exposure level by a factor of four.

Illustration 3: Distance for radioactive exposure

Exposure at 2 feet **Exposure at 4 feet**



If an individual sits four feet from the radiation source, the exposure level will be one-quarter the level, than if the same individual sat two feet from the radiation source.

3. Shielding

Shielding is used to absorb the radiation between the employee and the radiation source, thus the greater the shield around the radiation source will result in less exposure. The amount of shielding required to protect employees depends on the different kinds of radiation and their energy levels.

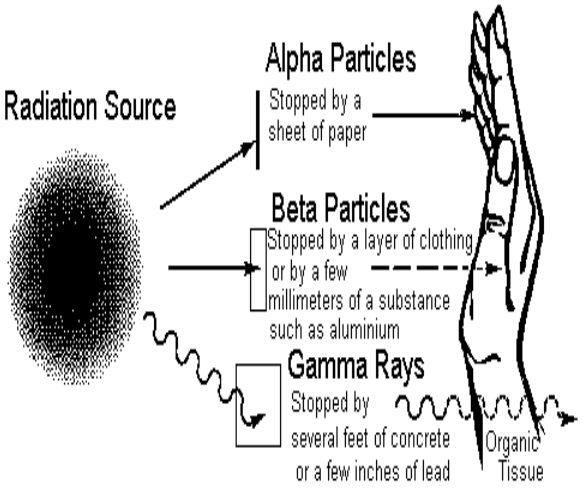


Illustration 4: Shielding

α (Alpha) — Alpha particles cannot penetrate a light material such as paper or dead cells on the outer layer of human skin thus providing adequate shielding. But if ingested or inhaled, there is no protection for the body tissues against alpha emitters.

β (Beta) — Heavy clothing is required to protect an employee against beta-emitters.

γ (Gamma) — A thick shield such as lead is required for protection against gamma rays.

2.3 Exposure – Internal

Internal exposure results from the absorption, ingestion or inhalation of radioactive material. This material can be incorporated in the body in several ways:

a) Breathing radioactive gases, vapors or dust.

b) Consuming radioactive material transferred from contaminated hands, tobacco products, food, or drink.

c) Entering through a wound.

d) Absorption through the skin.

If radioactive material is ingested, inhaled or absorbed through the skin, it cannot be removed, one has to wait for it to decay or for the body to eliminate it. The body will eliminate the radionuclide according to the biological half-life.

Section 3:Responsibilities

The Radiation Safety Committee and the Environmental Health and Safety Office of Nova Southeastern University are responsible for the protection of personnel, students and the environment from the potential hazards associated with ionizing and non-ionizing radiation used in NSU operations or at any NSU facility. There is only one license for the university, and any individual or action which jeopardizes the license endangers the permission of all clinicians and researchers to utilize radioactive material at NSU. If, for any reason, the license is suspended or terminated, no staff member or principal investigator may use licensed radioactive materials until the license is reinstated. This license places a significant responsibility on each person who uses radioactive materials to conform to safe work practices, to conduct and complete all required compliance duties, however large or small these tasks may be.

3.1 Radiation Safety Committee

NRC and Bureau of Radiation Control regulations require the establishment of an administrative structure to supervise the possession and use of radiation sources within the University. This structure is independent of other administrative organizations and a component of this structure, the Radiation Safety Committee (Committee), is charged with ensuring that licensed material will be used safely and in accordance with applicable regulation and licenses. The Committee is responsible for the following:

a. To formulate and promulgate University policies concerning the acquisition, use, and disposal of radioactive material and radiation producing machines.
b. To establish administration controls to ensure compliance by individual users with University, State, and Federal regulations.
c. To review, in advance and grant or disapprove the use of radioactive material or radiation producing devices within the institution from the standpoint of radiation safety.
d. Prescribe special conditions and requirements as well as establish possession limits and restrictions which may be necessary to ensure radiation safety.
e. Prepare and circulate information on radiological safety as guidance to students and staff members.
f. Investigate incidents involving sources of radiation for the purpose of determining causes and means for preventing their recurrence.
g. Retain records of the actions taken in approving the use of radioactive materials and other sources of ionizing radiation and other transactions, communications and reports involved in the work of the Committee.
h. Delegate to the Radiation Safety Officer the authority to act for the Committee between meetings. The RSO will report all actions to the committee for review at appropriate intervals.
i. Review all plans for new building or structural modifications where radioactive material or radiation producing devices are to be used.
j. Recommend and implement procedures for radioactive waste disposal.

The Committee shall consist of at least five members of which one will be the Radiation Safety Officer (RSO). The committee will meet at least twice during a calendar year or whenever necessary. At least annually, a formal ALARA audit of NSU's Radiation Safety Plan will be conducted which will include a review of the safety procedures, past operations and the radiation

safety standpoint on the Human Use of Radioisotopes and Radiation. The goal of the audit will be to evaluate the ALARA program's success.

3.2 Radiation Safety Officer

The Radiation Safety Officer (RSO) is responsible for the overall Radiation Safety Plan. The duties and responsibilities of the RSO shall include, but are not limited to the following:

a. Act as NSU's liaison officer with the licensing agency on all licensing matters.
b. Responsible for the operational aspects of radiation safety to ensure compliance with rules and regulations as well all terms and conditions of the license and any other applicable regulation.
c. Administer the overall day-to-day radiation safety program.
d. Ensure that sealed and unsealed radioactive materials are used only by, or under the direct supervision of individuals who are authorized by the licenser, and that all workers / students wear personnel monitoring equipment when required.
e. Furnish guidance and direction to licensed material users on the safe operation and handling of radioactive materials and in the use of radiation survey instruments.
f. Emphasize the ALARA philosophy to employees, guide, instruct and train licensed users on the safe operation and handling of radioactive materials and in the use of radioactive survey instruments. In addition, guidance on relevant changes to reduce exposures.
g. Review the dosimetry reports for all monitored personnel to determine if unnecessary exposures are being received. Will investigate within 30 days the cause of any dose considered to be excessive and if warranted, take corrective action to prevent recurrence.
h. Compile and maintain a report of each investigation for inspection purposes. An annual written notification regarding exposures will be available to all monitored personnel.
i. Responsible for preparing and labeling the radioactive waste for transportation, will be trained and certified by NSU for this function at least every three years according to sections 64E - 5.1501 and 64E - 5.1502 of the Florida Administrative Code.
j. Maintain a list of all Authorized Users (AU).
k. Perform, at least annually, a formal review and audit to ensure the Radiation Safety Plan is being enacted as required by 64E - 5.303(3), F.A.C. The review will include an evaluation of equipment, procedures, dosimetry records, inspection findings and incidents. A report of each audit will be maintained on file for three years from the date of review.

The RSO will be the contact person for the Florida Department of Health for events such as loss, theft, or damage of radioactive materials.

All records will be permanently maintained as required by the Radioactive Materials License and the State of Florida, Department of Health which also regulates the use of X-ray producing equipment.

3.3 Authorized Users and Personnel

All personnel working with sources of radiation will apply ALARA principles and good work practices to minimize their occupational radiation exposures. TIME, DISTANCE and SHIELDING will be used so as to keep exposures ALARA. In other words, when working or

near sources of radiation, minimize time spent near the source, maximize the distance, and use shielding. All authorized users must:

a. Ensure that radioactive materials are used only as described in NSU's radioactive license and that no unauthorized use of radioactive material or equipment occurs.
b. Comply with radiation safety procedures and regulations.
c. Keep exposure as low as reasonably achievable (ALARA).
d. Maintain adequate inventory and utilization records.
e. Report any expected overexposures.
f. Notify the RSO if the personnel wish to declare pregnancy.
g. Ensure that all radioactive waste is properly disposed of.
h. Ensure the safe and secure storage of all radioactive materials.
i. Ensure that all required surveys and wipe tests are conducted.
j. Perform daily contamination surveys when radioactive materials are in use.

Section 4:License Requirements

Nova Southeastern University is licensed by the U.S. Nuclear Regulatory Commission (NRC) and the State of Florida, Department of Health, Bureau of Radiation Control (BRC) to procure, use and store radioactive material. The State of Florida, Bureau of Radiation Control also regulates the use of X-ray producing equipment including fluoroscopy, CT, accelerators and other units that emits ionizing radiation.

The Environmental Health and Safety Office maintains the licenses for the University, and is responsible for ensuring that the use of licensed material and other radiation producing equipment is in compliance with the conditions of the license, their associated procedures and other regulations. See Appendix A: State of Florida Application for Radioactive Material License.

The BRC is authorized to conduct inspections of licensees and to issue citations for violations. Citations may carry such fines, license restrictions, and license suspensions.

Section 5:Authorization and Procurement of Radioactive Materials

Requests to acquire and procure radioactive materials are prepared on the form "Application for Possession and Use of Radioactive Material or Equipment" (RSO-1; Appendix D) which is available from the Environmental Health and Safety Office. Requests are submitted to the Radiation Safety Committee (RSC) for approval via the RSO, and must be completed in sufficient detail so that the Committee can evaluate the request prior to approval.

The applicant should submit an experiment protocol or describe in the application those experimental or clinical procedures or actions that may affect or cause the inadvertent release or ingestion/inhalation of radioactive material. The applicant should also name any hazardous chemicals and compounds that will be used. Safety Data Sheets can be provided as guides for their safe use.

Approved applications are valid for the lifetime of the application, but must be reviewed each year so the current inventory is verified. Applicants will arrange with the RSO for the disposal or transfer of any remaining radioactive material on hand at the completion of work involving radioisotopes.

In order to expedite the approval of most applications, the Committee has designated the RSO in to authorize and approve applications considered to be routine in nature. The following specific uses are considered to be major in nature and will require review and approval of the entire Committee.

a) Applications for acquisition of hazard class I isotopes in quantities greater than 100 microcuries and hazard class II isotopes greater than 1 millicurie.
b) Applications for experiments or projects which involve substantial airborne hazards arising from gases, fine powders, or aerosols.
c) Applications for new installations or for major modifications to existing facilities involving the use of ionizing radiation sources.
d) Other applications for uses which the RSO feels should be brought to the attention of the full Committee.

Note: It will generally take a minimum of two to four weeks to arrange for the Committee to meet for review of applications in the categories above (Therefore, such applications should be submitted well in advance of the planned starting date.

5.1 Classification of Radionuclides According to Relative Hazard Potential

Class 1 (very high toxicity)

$^{90}Sr+^{90}Y$	^{210}Po	^{211}At	^{226}Ra	^{227}Ac	^{228}Th	^{229}Th	^{230}Th	^{231}Th
$^{210}Pb+^{210}Bi$	^{233}U	^{238}Pu	^{239}Pu	^{241}Am	^{242}Cm	^{252}Cf	Other transuranic	

Class 2 (high toxicity)

^{45}Ca	^{47}Ca	^{59}Fe	^{60}Co	^{85}Sr	^{91}Y	$^{106}Ru + ^{106}Rh$
^{125}I	^{131}I	^{151}Sm	^{152}Eu	^{154}Eu	^{170}Tm	$^{140}Ba + ^{140}La$
^{232}Th	^{109}Cd	^{115}Cd	^{203}Hg	^{207}Bi	^{89}Sr	$^{144}Ce + ^{144}Pr$

Natural thorium, natural uranium

Class 3 (moderate toxicity)

^{22}Na	^{24}Na	^{32}P	^{33}P	^{35}S	^{36}Cl	^{42}K	^{46}Sc	^{47}Sc	^{48}Sc	^{48}V
^{56}Mn	^{55}Fe	^{57}Co	^{58}Co	^{59}Ni	^{63}Ni	^{64}Cu	^{67}Cu	^{65}Zn	^{67}Ga	^{68}Ga
^{76}As	^{82}Br	^{85}Kr	^{84}Rb	^{86}Rb	^{90}Y	$^{95}Zr + ^{95}Nb$		^{95}Nb	^{99}Mo	^{99}Tc
$^{103}Pd + ^{103}Rh$		^{111}Ag		^{113}Sn		^{127}Te	^{105}Rh	^{129}Te	^{132}I	^{197}Hg
$^{137}Cs + ^{137}Ba$		^{143}Pr		^{147}Pm		^{166}Ho	^{133}Xe	^{177}Lu	^{182}Ta	^{181}W
^{192}Ir	^{191}Pt	^{193}Pt		^{196}Au		^{198}Au	^{183}Re	^{200}Tl	^{202}Tl	^{204}Tl
^{54}Mn	^{74}As	^{105}Ag		^{140}La		^{190}Ir	^{199}Au	^{203}Pb	^{51}Cr	^{72}Ga

Class 4 (slight toxicity)

^{3}H	^{7}Be	^{14}C	^{18}F	^{51}Cr	^{68}Ge	^{71}Ge	^{87m}Sr	^{99m}Tc
^{111}In	^{201}Tl	^{235}U	^{238}U					

These classifications are used as part of the evaluation of an application to determine the type of laboratory or workplace standards required. The toxicity ratings are extracted from various published data, but may have been shifted up or down when in the professional judgment of the health physicist local conditions indicate the need.

5.2 Amendment

All changes to existing permits must be requested by submitting a letter outlining the changes to the RSO and completing a Permit Amendment form (RSO-2). An amendment to the original investigator's authorization is required for changes of radionuclide, possession limit, place of use, protocol, and addition or deletion of individual users.

5.3 Transfers

The RSO shall be notified of any sealed or unsealed source of radioactive material that is to be transferred from one licensee to another, on or off campus. An RSO-3 (Radioactive Material Transfer Form) shall be submitted to the RSO. The RSO must be notified before the location of any sealed or unsealed radioactive material is changed, so as to ensure that the receiver of the radioactive material is authorized by the RSO and state.

The transfer of radioactive materials off campus must comply with the U.S. Department of Transportation regulations. The RSO or trained designee must check all shipments of low-level

radioactive materials or waste. Notification to the Bureau of Radiation Control must be made 48 hours prior to off-campus shipment of low-level radioactive waste.

All persons handling shipping or transportation activities for radioactive material which is regulated by Title 49, Code of Federal Regulations are required to be trained in the appropriate U.S. DOT Hazardous Material guidelines. Training is to be completed within 90 days of hire with refresher courses occurring every three years. Training certifications are to be retained on a permanent basis.

5.4 Procurement

The acquisition of radioactive materials by purchase order, transfer, or gift requires prior approval from the RSO. All radioactive materials must be shipped to the RAM authorized lab.

A Radioactive Material Request (RSO-4) form must be submitted to the RSO. The RSO authorizes the procurement of the material after verifying that the Authorized User is approved to receive the type of material ordered and that the requested amount does not exceed the possession limit. Once approval is received, the order may be submitted.

5.5 Receiving

All packages will be received by the Authorized User in order to check for leakage, contents and package integrity. Only RAM trained users can accept radioactive packages. The RSO-4 form must be updated to document the condition of the package. Completed RSO-4 shall be sent to the RSO promptly and the Authorized User will update their inventory log recording the new shipment.

5.6 Facilities

Radioactive materials or producing equipment are not to be used in any University facility without approval of the Radiation Safety Committee and/or the Radiation Safety Officer from the standpoint of radiation safety. Plans for all new buildings and reconstruction of existing structures, where radioactive materials or equipment are to be used, must be approved by the Radiation Safety Committee prior to construction or modification of the premises.

Prior to termination of radionuclide activity or radioactive producing equipment, the Radiation Safety Committee must be notified in order to assure that the facility is free from contamination and that transfer material is in accordance with regulations.

Section 6:Training

Before any project using sealed or unsealed sources of radioactive material is initiated, all personnel associated with the project are required to become certified with the rules and regulations concerning the use of radioactive material as reported in this plan. This Radiation Safety Plan shall be presented to all personnel involved in the handling of radionuclides or any kind of ionizing radiation sources.

The Radiation Safety Committee (RSC) will review the completed application and establish that the working area and equipment are adequate for the project. In addition, each user has to submit a Statement of Training and Experience (RSO-5) form, providing evidence to the RSC of training in radionuclide basics and handling procedures.

Training will be provided for all staff members who use radioactive materials and radiation producing equipment. The radiation safety course will cover the basic principles and practices of radiation protection. In addition, the course will discuss radioisotope usage, waste and disposal of radioactive material, radioisotope theory and measurement, and the biological effects of radiation.

The RSO will determine the necessary training for the individuals based on their use of radioisotopes and their potential for exposure. In some cases, a test may be used to assess the user's knowledge. See Appendix I for an example of a Radiation Safety quiz.

6.1 Frequency of Training

Training will be conducted under the following scenarios:

a) Before assuming duties with, or in the vicinity of, radioactive materials (for users and awareness-level employees).
b) Whenever there is a significant change in duties, regulations, or the terms of the license (for users and awareness-level employees).
c) Periodic refresher training (for users). Refresher training will be conducted every 2 years.

6.2 Training Topics

Topics may include all or some of the following depending on the individual's use of radioisotopes, and potential for exposure:

1. Radiation safety

a) Radiation vs. contamination
b) Internal vs. external exposure
c) Biological effects of radiation
d) ALARA concept
e) Use of time, distance, and shielding to minimize exposure

2. Regulatory requirements

a) RSO
b) Material control and accountability
c) Personnel dosimetry
d) Radiation safety program audits
e) Transfer and disposal
f) Record keeping
g) Surveys
h) Postings
i) Labeling of containers
j) Handling and reporting of incidents or events
k) Licensing and inspection by NRC/Bureau of Radiation Control
l) Need for complete and accurate information
m) Employee protection
n) Deliberate misconduct

3. Additional licensee-specific program elements

Additional licensee-specific program elements may need to be covered which may include all or some of the following:

a) Authorized users: this includes control procedures for obtaining permission to use radioactive materials at the facility and limitations on quantity to be handled per user and allowed per experiment.
b) Ordering and receiving radioisotopes: this includes instructions concerning transfer of licensed materials between rooms, halls, or buildings, if applicable.
c) Applicable regulations and license conditions.
d) Areas where radioactive material is used or stored: this includes requirements of storage, labeling of containers, and identification of areas where licensed materials are used.
e) Potential hazards associated with radioactive material in each area where the individuals will work.
f) Appropriate radiation safety procedures: this includes reviewing necessary protective clothing and what laboratory apparel to wear and what equipment to use. This includes prohibition of pipetting by mouth, eating, smoking, and drinking in areas where licensed materials are used.
g) Licensee's in-house work rules.
h) Each individual's obligation to report unsafe conditions to the RSO.
i) Appropriate response to spills, emergencies or other unsafe conditions.
j) Worker's right to be informed of occupational radiation exposure and bioassay results, if applicable.
k) Locations where the licensee has posted or made available: notices, copies of pertinent regulations, and copies of pertinent license and license conditions (including applications and applicable correspondence), as required by 10 CFR Part 19 "Notices, Instructions and Reports to Workers: Inspection and Investigations".
l) Emergency procedures which include but are not limited to: RSO name and telephone number; immediate steps to prevent or control spread of contamination; clean-up instructions; and decontamination.

m) Survey program
    i. Survey instrument accessibility
    ii. Who is responsible
    iii. Types, contamination and area
    iv. Frequency
    v. Levels of contamination
    vi. Personnel, hands, shoes
    vii. Records
n) Waste
    i. Liquid
    ii. Solid
    iii. Sanitary sewer
    iv. Burial (transfer to low level waste repository)
    v. Storage
    vi. Decay-in-storage
    vii. Waste storage surveys
    viii. Records
o) Dosimetry
    i. Whole body
    ii. Extremities
    iii. Lost or replacement badges and dose assessment
    iv. Bioassay procedures
    v. Records
p) Instrumentation such as survey meters- use, calibration frequency, use of check sources; analytical instruments- liquid scintillation counters; and radiation producing machines
q) Procedures for receiving packages containing radioactive materials
    i. Normal
    ii. Off-duty
    iii. Notification of user and RSO
    iv. Security
    v. Exposure levels
    vi. Possession limit
    vii. Receipt of damaged packages
r) Procedures for opening and examining packages
    i. Leakage and contamination
    ii. Monitoring packages
    iii. Monitoring packing materials
    iv. Gloves
    v. Transferring material to users
s) Sealed sources
    i. Leak test requirements
    ii. Inventory requirements
    iii. Exempt quantities
    iv. Records

Section 7:Personnel Monitoring and Occupational Dose Limits

Nova Southeastern University is committed to the concept of personnel radiation exposures being as low as reasonably achievable (ALARA) and the following guidelines shall be observed:

7.1 Dose Restrictions for Radiation Employees

Personnel shall constantly review their work habits and available safety equipment for adherence to the ALARA principle and state regulations (64E-5. F.A.C). The RSO will notify individuals when personnel exposures exceed ALARA limits. These exposures will be investigated and reviewed by the RSC. The RSO will investigate any individual's dose in excess of 125 mrem whole body or 1275 mrem to the extremities in any quarter.

The radiation dose to minors and an embryo/fetus shall not exceed 10 percent of the limits stated below (0.5rem or 500mrem for a whole body dose). The radiation dose to all other employees working with radiation shall not exceed an annual total effective dose equivalent of:

5 rem (5000mrem) to the body; or
15 rem (15,000mrem) to the eye; or
50 rem (50,000mrem) shallow dose to the skin or any extremity.

A pregnant employee is encouraged to inform her employer, in writing, of her pregnancy and the estimated date of conception. The pregnant employee shall wear a radiation badge at waist level while at work and the dose to an embryo or fetus during the entire pregnancy shall not exceed 0.5 rem (per 64E-5.311(5), F.A.C.). It is recommended that no more than 0.05 rem be received by the embryo or fetus in any one month.

The dose to an embryo or fetus shall be taken as the sum of the following:

a) The "deep dose equivalent" to the declared pregnant women and
b) The dose to the embryo or fetus from radionuclides in the embryo or fetus and radionuclides in the pregnant women.

By the time, the employee declares pregnancy, if the dose to the embryo or fetus has exceeded 0.45 rem, the exposure for the remaining period of the pregnancy shall not exceed dose to the embryo or fetus of 0.05 rem.

7.2 Dose Restrictions to Individual Members of the Public

All operations involving the use of radiation shall be conducted in such a way to restrict the total effective dose equivalent to individual members of the public (non-radiation workers) as follows:

0.05 rem (50 mrem) per year; or
2 mrem in any one hour.

Concentrations of radioactive materials in gaseous and liquid effluents shall not exceed 10 percent of the values specified in Table 2 of 64E5.313 (2) (b) 1, Florida Administrative Code.

7.3 Personnel Monitoring and Dosimetry

1. External Exposure

Personnel monitoring devices are provided by EHS through the RSO to measure an individual's radiation exposure to gamma, energetic beta and X-ray sources. The standard monitoring device is issued as a clip-on badge (whole body film badge or thermoluminescent dosimeter [TLD]) or ring badge bearing the individual's name, date of the monitoring period and a unique identification number. The dosimeters are provided, processed and reported through a commercial service company that meets current requirements of the National Institute of Standards and Technology National Voluntary Laboratory Accreditation Program (NVLAP).

a) Whole Body film /TLD Badges (clip-on) shall be worn when:

   i. using or assisting in the use of unsealed sources of a beta emitter where the maximum beta energy is 1000 keV or higher.
   ii. using or assisting in the use of unsealed sources of a gamma emitter where the gamma ray energy is 25 keV or higher.
   iii. working with neutron sources. Special neutron badges may be required in addition to other badges.
   iv. specified by the RSC and/or the RSO.

All personnel entering areas where a whole-body personnel dosimeter has been deemed to be appropriate shall wear the device in the position that will likely indicate the highest whole body dose (e.g., between chest and waist level, outside of clothing).

b) Extremity badges or rings shall be worn when:

   i. an individual is using or assisting in the use of unsealed sources of radioactive materials of 1,000 microcuries (37 MBq) or more of beta-emitting radionuclides with a maximum beta energy of 1,000 kiloelectron volts or more in any month.
   ii. an individual receives a dose of 40 millirem (400 uSv) or more on a whole body film badge or TLD for 2 consecutive months while working with unsealed sources.
   iii. Specified by the Radiation Safety Committee and/or the RSO.

Personnel working with radioactive materials, that are issued an extremity dosimeter (ring TLD), shall wear the dosimeter under a glove on a finger with the sensitive portion of the dosimeter toward the palm of their hand; i.e., closest to the source of radiation, so that the finger does not shield the dosimeter from the radiation. Those working with other sources of radiation, e.g., x-ray diffraction units, shall wear the ring dosimeter with the sensitive portion on their finger facing the radiation source. Ring dosimeters shall be worn under gloves when necessary to prevent device contamination.

All monitoring devices shall be obtained from EHS. Each film/TLD badge shall be assigned to and worn by only one individual and may be exchanged monthly, bi-monthly, or quarterly depending upon monitoring device wear location and expected radiation exposure. Delivery, exchange and pickup of badges shall be the responsibility of the RSO.

In the event, that a monitor is damaged, lost, or accidentally exposed, it is the responsibility of the Investigator or employee to notify the RSO immediately for monitor replacement or processing. Permanent records of monitor readings are maintained by EHS.

c) Pocket Dosimeters

Pocket dosimeters are used to provide the wearer with an immediate reading of his or her exposure to x-rays and gamma rays. As the name implies, they are commonly worn in the pocket.

Pocket dosimeters may be required to be worn in addition to the film badge if other types of monitors are inadequate in the judgment of the RSO. This shall apply where the investigator is working in a high radiation area or in some instances, working with high level radioactive materials or other ionizing radiation. When these devices are used, the Investigator is responsible for maintaining daily pocket dosimeter records.

It is imperative to use dosimeters only as prescribed because these records are legally presumptive evidence of personal exposures. The Radiation Safety Committee or the RSO may require the use of dosimetry in situations that would not ordinarily justify their use when it appears to be in the best interests of NSU.

It is the responsibility of each individual anticipating use of ionizing radiation to provide the RSO with a copy of his occupational exposure record for all radiation exposures received before coming to NSU. Personnel working with radioisotopes may be required to wear protective garments to prevent contamination.

TABLE B: Dosimeter Precautions

DO store dosimeters away from radiation sources when not in use.
DO protect dosimeters against contamination (e.g. wear finger rings under gloves, etc.)
DO NOT use any dosimeter without an appropriate badge holder.
DO NOT wear a dosimeter without the printed information facing away from the part of the body where the highest dose is expected.
DO NOT wear a NSU-issued dosimeter at any facility other than NSU.
DO NOT intentionally expose your dosimeter to radiation, to just "test" it.
DO NOT dispose of a dosimeter. If a dosimeter is no longer needed, return it to the Radiation Safety Officer.
DO NOT puncture or cut a dosimeter with staples, scissors, tacks, etc.
DO NOT expose the dosimeter to hazardous chemicals, liquids, or excessive heat.
DO NOT loan a dosimeter to anyone. DO NOT borrow anyone else's badge.

2. Internal Exposure

All uses of radioactive materials will be evaluated for potential internal exposure as part of the review and renewal process. Isotope possession limits, work practices and/or engineering controls may be implemented or modified to prevent the need for bioassays. Bioassay will be available in the event of an emergency release.

a) Bioassay

A bioassay is a means of determining internal exposure through analysis of body fluids (in vitro) or direct measurement (in vivo). An example of an in vitro bioassay is a urinalysis. An example of an in vivo bioassay is a thyroid scan, a procedure in which the amount of radiation present is determined by holding a detector directly to the thyroid gland.

Bioassay services will be needed if any of the following materials are used:

- **^{3}H –** Have your urine assayed every 2 weeks if more than 100 mCi of a volatile form of ^{3}H is used per month. The EHS office will report positive analytical results to you as soon as results are available.

- **Volatile iodine –** Participate in the thyroid monitoring program if you use more than 10 mCi of volatile iodine per month. Monitoring frequency depends on the specific isotope of iodine:

  - **^{123}I –** At least 6 hours after, but within 2 days of a procedure.

  - **^{125}I –** At least 6 hours after, but within 30 days of a procedure.

  - **^{131}I –** At least 6 hours after, but within 5 days of a procedure.

- **Performing multiple iodinations –** A single bioassay is acceptable, as long as the time from the first iodination to the time of the bioassay doesn't exceed the limits listed above.

Employees who are wanting to have a bioassay even though they're not required to, or because they suspect an uptake during a large spill, can contact EHS Office.

TABLE C: Bioassay Requirements

Isotope	Physical Form	Recommended Bioassay Level (mCi/month/person)	Type of Bioassay
^{14}C	Liquid	1,700	Urine sample
^{3}H	Liquid	670	Urine sample
^{125}I	Volatile	0.33	Thyroid count
^{131}I	Volatile	0.25	Thyroid count
^{32}P	Liquid	500	Urine sample

^{33}P	Liquid	2,500	Urine sample
^{35}S	Liquid	1,700	Urine sample
^{35}S	*Volatile	170	Urine sample

A baseline bioassay should be completed prior to performing experiments that require internal exposure monitoring according to the criteria below.

b) Radioactivity levels for participation in Bioassay (Appendix E)

Individuals will be monitored for intake of radioactive material when the following doses or exposure are likely:

ADULTS: Likely to receive, in one year an intake in excess of 10% of the applicable Annual Limit on Intake (ALI) (10 CFR 20 appendix B).

MINORS AND DECLARED PREGNANT WOMEN: Likely to receive, in one year, a committed effective dose equivalent (CEDE) in excess of 0.05 rem.

Radioactive materials users handling unsealed ^{125}I or ^{3}H will participate in a bioassay program when activities handled exceed the following:

TABLE D: Radioactivity Levels for Iodine - 125 Requiring Bioassay

Process Area	Volatile or Dispersible	Bound to Non-volatile agent
Open room or bench top	1 mCi	10 mCi
Fume Hood	10 mCi	100 mCi
Glove Box	100 mCi	1000 mCi

Radioactivity Levels for Tritium - H3 Requiring Bioassay			
Process Area	Tritiated Water or Tritiated Compounds	Tritium Gas in Sealed vessels	Tritium Nucleotide Precusors
Open room or bench top	0.01 Ci	100 Ci	10 mCi/kg
Fume Hood	1 Ci	1000 Ci	100 mCi/kg
Glove Box	10 Ci	10,000 Ci	1 Ci/kg

c) Emergency Bioassay

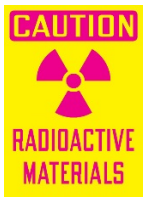
Emergency bioassay will be conducted in the event of an accident in which an employee /student has likely received an intake in excess of the 10% ALI. A minor or declared pregnant woman who has likely received a committed effective dose equivalent in excess of 0.05 rem.

When an emergency bioassay is needed, the exposed individual will be decontaminated as close as practicable to the release site to prevent the spread of the contamination. The RSO will supervise this decontamination with the assistance of Public Safety Office as needed.

Section 8:Signs and Labels

8.1 Area Restriction

All rooms or areas in which licensed quantities of radioactive materials or radiation equipment are used or stored must be posted with a "Caution Radioactive Material" sign or "Caution High Radiation Area" sign, an "NRC Licensing and Regulation Information Bulletin" sign, and a "Notice To Workers" sign (Appendix C - State of Florida "Notice To Workers").



Door signs must include the Authorized User's name and phone number, and where he or she can be reached in the event of an emergency. Postings can be obtained from the RSO.

a) Definitions Of Area Restrictions (10 CFR 20.1003)

Unrestricted Area: An area or access to which is neither controlled nor restricted by the licensee.

Restricted Area: An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. A restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be used as a restricted area.

Controlled Area: An area, outside of a restricted area but inside of the site boundary, access to which can be limited by the licensee for any reason.

a. **Radiation Area:** An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem in 1 hour at 30 centimeters from theradiation source or from any surface that the radiation penetrates.
b. **High Radiation Area:** An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 100 mrem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.
c. **Very High Radiation Area:** An area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads* in 1 hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

At Nova Southeastern University, most of the radiation use areas on campus are managed as restricted areas. Members of the public are permitted to be present, as long they are escorted by a trained worker while in the restricted area or have been trained in radiation safety to work

independently. Authorized User training accomplishes training requirements for workers frequenting the laboratory but not handling radioactive materials.

Within the restricted area, it is imperative that strict surveillance be maintained to assure that significant exposure levels are not present, whether in the form of contamination, airborne levels of radiation or external exposure levels.

Other radiation area restriction categories (radiation area) exist only in a few specific locations, which are typically not accessible to the general public. In the event of emergency or other unusual situations, any of the restricted areas may be restricted to a more secure level to protect against radiation or any other hazard which may be present. If this were to occur, the area(s) would be clearly marked and posted with warning signs or barriers.

8.2 Labeling Requirements

Work areas, trays, racks, stock solutions, tools, equipment, etc., which contain radioactive material or are contaminated must be labeled with radioactive materials tape or "Caution Radioactive Materials" sign. The label must contain the radioisotope present, date, and the total activity in disintegrations per minute (DPM) or microcuries. It is not reasonable to expect that each tube or vial be labeled, but the container, tray or rack that holds them must be labeled. (For example, scintillation vials do not need to be individually labeled, but the tray or box that they are stored in must have the above described label).

The "rule of thumb" is that if there is radiation above the background in or on something, it must be labeled.

a) For contaminated equipment which is in frequent use, the isotope, date and maximum activity which may be present at any given time is to be written on the radioactive warning label.
b) For equipment which is used for radioactive materials, but is not contaminated (equipment which the staff wishes to identify for radioactive use), a label with the radioactive materials warning, "Caution, Radioactive Materials", may be used.
c) Labels are not required if the equipment is not contaminated.

All radioactive waste must be similarly labeled with the above described information. Bench top waste containers are to be labeled in the same method as for radioactive materials in use or storage. As soon as radioactive waste is placed in the radioactive waste container, all information on the waste tag must be filled out.

TABLE E: DOT Radioactive Labels

RADIOACTIVE WHITE – I	Label means practically no radiation outside the package	
RADIOACTIVE YELLOW-II	Label means some radiation outside the package	
RADIOACTIVE YELLOW - III	Label is for higher radiation levels than RADIOACTIVE I and II.	

Section 9:Inventory and Storage

Each investigator or supervisor is responsible for providing quarterly radioactive material inventory reports to the RSO. Inventory records shall be maintained permanently by the investigator or supervisor for review by the Committee and DOH/Bureau inspectors. Inventory record forms are available from EHS.

The RSO will perform an annual physical inventory of all radiation producing devices to confirm registration with DOH. Each investigator or supervisor is responsible for notifying the Committee if there are any changes which would render the registration inaccurate. Such information includes: change of use location, sale, transfer or disposal of any radiation machine or major component thereof.

9.1 Storage

Radioactive materials/waste must be stored in containers that provide adequate shielding for the isotope being stored. Radioactive materials/waste must be stored separately according to isotope.

Radioactive material must be stored in refrigerators, cold rooms, freezers or fume hoods that are properly labeled. The RSO will place a sign on all refrigerators, cold rooms, or freezers used to handle or store radioactive material indicating that no food or drink is to be stored within. Radioactive materials must be stored in a secure area unless under the direct supervision of an approved worker or authorized user.

Volatile radioactive materials must be stored (and used) in a properly functioning glove box or fume hood with exhaust to outside atmosphere.

Liquid radioactive material is to be stored in sturdy plastic containers, not glass, to lessen the chance of breakage. The container must have a screw-top lid. Beverage containers should not be used. The container should be labeled as to content including isotope and chemical constituents.

Section 10: General Radiation Safety Guides

10.1 General Radiation Safety Guides for Radioactive Material Use

a) The procedure for each project/research should be well outlined in writing for all laboratory personnel. Necessary equipment, waste containers, and survey instruments must be available.

b) Characteristics of the radioactive material such as type of radiation, energy, half-life, significant and typical amounts, and chemical form should be known.

c) In some cases, before the procedure is actually performed with radioactive material, a "dry run" practice of the procedure may be useful to avoid problems.

d) A radiation employee should supervise visitors and students in a laboratory that uses radioactive material.

e) Personnel monitoring badges shall be worn in controlled areas, as applicable.

f) Radioactive waste shall be disposed of only in the containers provided. Non-standard containers are prohibited.

g) Stock shipments shall be handled and stored in specially designated locations.

h) Radioactive material must not be left unattended in places where it may be handled or removed by unknowing and unauthorized persons. All lab rooms and waste storage areas must be locked when unattended.

i) As a general practice, work with radioactive material should be confined to only the areas necessary. This simplifies the problem of confinement and shielding, and aids in limiting the affected area in case of an accident.

j) All work surfaces and storage areas (tabletops, hoods, floors, etc.) should be properly covered. Some older facilities are very difficult to decontaminate.

k) Absorbent mats or paper should be used. Protective absorbent with a plastic back and absorbent front is especially useful. If contaminated, it can simply be discarded in the radioactive waste container.

l) Spillage should be preventable, but in the event of such an accident, follow the established emergency procedures.

m) Conduct radiation meter and wipe test surveys frequently. When measurements are abnormal, find the cause and correct.

n) Plastic or metal trays (stainless steel washes easily) should be placed on the surface when liquids are to be used. The tray serves to confine a spill and must be suitable to contain the total volume in use.

o) Good housekeeping must be practiced at all times. If an area is kept neat, clean, and free from equipment not required for the immediate procedure, the likelihood of accidental contamination or unnecessary exposure is reduced.

p) Radioactive material, especially liquids, should be kept in unbreakable containers whenever possible. If glass is used, a secondary container must be provided.

q) NEVER PIPETTE BY MOUTH! Always use a mechanical pipette filling device.

r) Eating, drinking, smoking, application of cosmetics, or storing of food is prohibited.

s) Refrigerators used to store radioactive material shall not be used for the storage of food. All storage compartments (refrigerator and freezer sections) must be conspicuously posted with radiation warning stickers.

t) Smoking is not permitted in radioactive areas.

u) Wash hands thoroughly after working with or near radioactive materials and before eating, drinking, smoking, or applying cosmetics.

v) Protective gloves must be worn any time an unsealed radiation source is being used. Do not use the telephone, handle books, or open cabinets with contaminated gloves. If there is a break in the skin on the hand, be sure to wear gloves.

w) Lab coats and appropriate shoes must be worn by all individuals handling radioactive material.

x) All reusable glassware and tools used with radioactive material should be thoroughly cleaned after use and kept separate from non-contaminated items. It is recommended that a marked container or area be provided for glassware and tools used in radioactive work.

10.2 Eating, Drinking and Smoking Policy

Contamination of food, drink, tobacco products, and cosmetics is a potential route for ingestion of a hazardous substance. Food is to be stored, handled and consumed in an area free of hazardous substances. Non-laboratory areas, such as nearby break rooms, lounges or conference rooms are to be designated as food storage and eating areas for laboratory personnel. The NSU Chemical Hygiene Plan states there shall be no eating, drinking, smoking, chewing of gum or tobacco, application of cosmetics or storage of utensils, food or food containers in laboratory areas where chemicals, carcinogens and toxins are used or stored.

10.3 General Radiation Safety Guides for Radiation Producing Machine

a) Each individual intending to operate any radiation producing machine must be trained in its use by an individual familiar with the system.

b) Each individual working with a radiation machine should know exactly what work is to be done and which applicable safety precautions should be used.

c) Written operating and safety procedures must be available to personnel before operating radiation machines.

d) Visitors and students in the area of work should be supervised by the equipment operator.

e) Radiation producing machines must not be left unattended in an operational mode

f) Structural shielding requirements for any new installation, or any modifications to an existing unit or room, must be approved by the Radiation Safety Committee before the machine is placed in service.

g) When the safe use of the equipment depends on the mechanical set up of the unit or on technique factors, these restrictions should be closely followed.

h) Under no circumstances shall shutter mechanisms or interlocks be defeated or in any way modified except in accordance with approved written procedures.

i) All warning lights should be "fail safe" (specific regulations require "fail safe" features).

j) A manually reset cumulative timing device should be used to indicate elapsed time and to turn off the machine when the total exposure reaches the planned amount.

k) Special care is needed when working with x-ray diffraction units. Exposure rates in the primary beam can be in excess of 500,000 rems per minute at the x-ray tube. Specific procedures for training, operation and emergency response developed for these devices.

l) Some machines such as analytical x-ray devices, irradiators and accelerators have individual safety programs. Detailed operating and emergency procedures must be posted and followed.

m) Proper maintenance on all radiation producing equipment is essential. Only properly trained technical staff shall perform repairs to these instruments. Service personnel must be licensed or registered by the State of Florida.

Section 11: Contamination Surveys

"Survey" means an evaluation of the radiation hazards incident to the use, release, disposal and presence of radioactive materials and other sources under a specific Authorized User. A survey should include measurements of external radiation levels near sources in use, storage, waste containers, etc. and of removable contamination by wipe testing. Both restricted and adjacent unrestricted areas should be included. Routine laboratory surveys are required in research, clinical and teaching laboratories to detect excessive radiation levels and/or contamination in order to alert laboratory personnel to potential hazards.

11.1 Survey Frequency

The laboratory must be surveyed for contamination after each use of radioactive material or at the end of the day. At least one such survey must be recorded WEEKLY. This is a minimum requirement; more frequent surveys (where appropriate) are encouraged.

TABLE_F: Survey Frequency

Radiation Type:	Examples:	Survey Frequency:
Beta (<200 KeV)	H-3, C-14, S-35	Weekly
Beta (>200 KeV)	P-32, P-33	Daily
Gamma	I-125, I-131	Daily

Contamination surveys do not need to be performed during periods when no radioactive materials are used.

11.2 Survey Method

Contamination surveys can be conducted using a variety of methods. The two most common methods are "area" and "wipe" surveys.

a) Area Survey: Measures both fixed and removable contamination and are performed with a portable radiation survey meter. Meter surveys using Geiger detectors or scintillation probes, can identify gross contamination (total contamination consisting of both fixed and removable contamination) but will detect only certain isotopes.

b) Wipe Survey: Measures only removable contamination and is performed by wiping a surface with a small "wipe" and then counting the wipe with an appropriate counting device.

It is important to select and use a contamination detection instrument that is appropriate for the type of radioactive material being used.

TABLE G: Survey Methods for Radioisotopes

Radioisotope	Acceptable Survey Method	Comments
H-3	LSC	There are no other acceptable survey methods
C-14	G-M or LSC	LSC is most sensitive; G-M detects moderate to high levels of contamination; do not cover G-M with parafilm
P-32	G-M or LSC	G-M detects low levels of contamination
P-33	G-M or LSC	LSC is most sensitive; G-M detects moderate to high levels of contamination; do not cover G-M with parafilm
S-35	G-M or LSC	LSC is most sensitive; G-M detects moderate to high levels of contamination; do not cover G-M with parafilm.
Cr-51	NaI, g, or LSC	
Zn-65	G-M or g	
I-125	NaI, g, or LSC	
U-238	G-M or LSC	

Table Key:
G-M = Survey meter with a Geiger-Muller detector
LSC = liquid scintillation counting
NaI = survey meter with a thin crystal sodium iodide detector
g = gamma counter

11.3 Conducting the Survey

When conducting contamination surveys, it is important to avoid contaminating yourself and/or the survey equipment. Methods include the following:

1. Area Surveys

At NSU the most common type of survey instrument that will be used is a Geiger-Muller (G-M) detector. The portable G-M survey meter is best used for ^{32}P, a high energy beta emitter, and other high energy beta and gamma emitters, such as ^{60}Co, ^{65}Zn, ^{137}Cs, and ^{238}U. A G-M meter can also be used to identify areas heavily contaminated with lower energy betas, such as ^{14}C or ^{35}S, for which the G-M meter has a relatively low efficiency.

G-M meters should not be used to survey for ^{125}I contamination, since G-M meters will detect ^{125}I only when there are very high levels of contamination.

The portable thin crystal NaI scintillation survey meter is used to locate ^{125}I contamination and to conduct surveys around low-energy X-ray sources such as X-ray diffractometers and electron microscopes.

The liquid scintillation counter, used for counting wipe tests, is not portable but is the most versatile counting instrument because it has a high counting efficiency for a wide range of radionuclides.

Gamma counters are not portable and are used to count wipe tests for photon emitters, such as ^{51}Cr or ^{125}I.

Meter Survey Method:

a. Check the survey meter's battery by turning the meter knob to the battery test position. If the battery is adequately charged, the meter needle will swing to the battery test position on the meter face. Replace the batteries if the batteries are low.
b. Perform an operational check the first time you use the meter each day or when you suspect it may have been misused or damaged. Look at the calibration sticker on the side of the meter and note what the expected reading for the operational check source should be. Turn the meter on and turn the meter's multiplier switch to a setting that will measure the check source and will provide a mid-scale reading but will not cause the needle to swing beyond full scale. Place the probe firmly against the check source on the side of the meter and note the meter response. If the observed meter response differs from the expected response by more than 20%, the meter should be considered nonfunctional and should be taken out of service.
c. Take the meter to an area away from sources of radiation and note the meter background reading. Typically, the background for a G-M meter with a pancake survey probe should be less than 100 counts per minute (cpm) while the background reading for a meter with a NaI scintillation crystal should be less than 300 cpm. If the meter's background reading is substantially greater than expected, confirm that there are no unexpected sources of radiation or radioactive materials in the vicinity, and then call Environmental Health & Safety (EHS) Office to report a contaminated meter.
d. Do not cover the probe surface with parafilm or other protective covering. Parafilm and similar materials will shield the low energy betas from C-14, P-33 and S-35 and will prevent the meter from detecting contamination.
e. Slowly move the probe about 1 centimeter above the area of interest.
f. If an item or area with a sustained count rate more **three times background** is found, the item or area should be considered to be contaminated.
g. Immediately label the area or item and promptly decontaminate it.
h. Sometimes, especially in the presence of other radioactive materials, the meter survey may be equivocal. When the meter survey indicates that low level contamination may be present, a wipe survey should be performed to confirm or disprove the presence of contamination.

i. Document the survey results whenever contamination is discovered or if 250 μCi or more have been handled. Record survey results in the Area Survey Report. **This is a University requirement.**

2. Wipe Surveys

Wipe surveys must be performed when H-3 is used and is the survey method of choice to detect the presence of low levels of removable C-14, P-33 and S-35 contamination. Wipe surveys should also be performed to confirm the presence of contamination when a meter survey suggests that low level contamination may be present.

Wipe survey method:

a. Using a piece of filter paper (about 5 cm^2 or 1" in diameter), Q-tip or other swab, wipe the area being surveyed. If the area is very large, subdivide it into smaller areas and use several wipes to better pinpoint the location of contamination. For some surfaces, including skin and clothing, the wipe media should be moistened with water or other appropriate solvent.
b. Prepare the sample for counting as suggested in the counter's operating manual. Analyze the wipe samples in a liquid scintillation counter for H-3 and other beta emitters and preferably in a gamma counter for Cr-51 and I-125.
c. Sample activity is determined by dividing the sample count by the counter's efficiency for the isotope in question. The counter's operating manual should provide information about efficiencies and activity determination.
d. Call EHS Office with questions about liquid scintillation and gamma counter use.
e. Results exceeding 100dpm/100cm^2 must be decontaminated.

11.4 Radiation Survey Meters

Calibrated survey meters which are appropriate for the type and level of ionizing radiation being used must be available. Survey meters must be calibrated every 12 months. Contact EHS for instrument calibration and minor repair services.

11.5 Leak Test

Leak tests will be performed at the intervals approved by NRC as follows:

a) For each source to be tested, list identifying information such as manufacturer, model number, serial number, radionuclides, and activity.
b) If available, use a survey meter to monitor exposure.
c) Prepare a separate wipe sample (e.g., cotton swab or filter paper) for each source.
d) Number each wipe to correlate with identifying information for each source.
e) Wipe the most accessible area (but not directly from the surface of a source) where contamination would accumulate if the sealed source were leaking.
f) Select an instrument that is sensitive enough to detect 185 becquerels (0.005 microcurie) of the radionuclides and ensure that its calibration is current.

g) Using the selected instrument, count and record background count rate.
h) Calculate efficiency.
i) Count each wipe sample; determine net count rate.
j) For each sample, calculate and record estimated activity in becquerels (or microcuries).
k) Sign and date the list of sources, data and calculations. Retain records for 3 years (10 CFR 20.2103(a) "Records of Surveys").
l) If the wipe test activity is 185 Bq (0.005 μCi) or greater, notify the RSO, so that the source can be withdrawn from use and disposed of properly.

The sealed and foil source(s) shall be tested for leakage and/or contamination at intervals not to exceed 6 months. Any source received from another person which is not accompanied by a certificate indicating that a test was performed within 6 months before transfer shall not be put into use until tested.

Notwithstanding the periodic leak test required by this condition, any licensed sealed source is exempt from such leak tests when the source contains 100 microcuries or less of beta and/or gamma emitting material or 10 microcuries or less of alpha emitting material.

Any source in storage and not being used need not be tested. When the source is removed from storage for use or transfer to another person, it shall be tested before use or transfer.

The test shall be capable of detecting the presence of 0.005 microcurie of radioactive material on the test sample. If the test reveals the presence of 0.005 microcurie or more of removable contamination, the source shall be removed from service and decontaminated, repaired, or disposed of in accordance with NRC regulations. A report shall be filed within 5 days of the date the leak test result is known with the NRC. The report shall specify the source involved, the test results, and corrective action taken. Records of leak test results shall be kept in units of microcuries and shall be maintained for inspection by the NRC. Records may be disposed of following NRC inspection.

Section 12: Disposal of Radioactive Wastes

12.1 General

Radioactive waste is not to be discarded by regular means of disposal. Specific rules, regulations, and guidelines (64E-5.328 through 333 FAC) must be followed for the disposal of radioactive waste. Emphasis is placed on the segregation of different types of waste according to radionuclide, half-life, chemical form, physical form, or combinations thereof. Radioactive Waste materials, which includes solid, bulk liquid, liquid scintillation vials, and animal carcasses resulting from the use of radioactive material in laboratories shall be stored in designated containers and retained for collection by the RSO. All radioactive wastes shall be disposed of in such a manner as to prevent the occurrence of a hazard to the health of NSU personnel, to the value of property, and to the welfare of the public. Final disposal of all radioactive wastes, with the exception of trace amounts through the sanitary sewer system, will be accomplished by the RSO.

12.2 Waste Types

There are basically four types of waste generated at NSU: dry solid, bulk liquid, liquid scintillation vials (LSV), and animal carcasses. In rare cases some predetermined operations may develop gaseous wastes.

a) **Dry solid wastes** containing radioactive materials are non-hazardous or hazardous. Dry solid radioactive waste that contains a hazardous component (mixed waste) cannot be generated without permission from the RSC. Otherwise, all dry solid waste must be in the chemical form that is non-hazardous and acceptable for disposal in the local landfill.
b) **Liquid wastes** are separated into two categories: (a) aqueous bulk liquids and (b) mixed waste (organic) bulk liquids.
c) **Aqueous liquids** are bulk liquids with a pH between 5 and 9, and which contain no biological, pathogenic, or infectious material, and have no hazardous characteristics. Aqueous biodegradable scintillation cocktails fall within this category. NOTE: Organic non-biodegradable scintillation fluids, hazardous liquids, as well as oils, other organic fluids, strong acids and bases are NOT considered aqueous fluids and should never be mixed with them.
    i. **Mixed (organic) bulk liquids** are radioactive bulk liquids that contain a hazardous component and meet the characteristics of hazardous material. Bulk liquids are considered mixed if they consist of hazardous chemicals such as toluene, xylene, or other flammable, toxic, or reactive fluids. NOTE: Regulations mandate that the generator (sub-licensee) be able to verify the contents of all wastes and their associated hazard classification.
    ii. **Liquid scintillation vials** are glass or plastic vials with a capacity of less than 50 ml each which contain, or have contained, liquid scintillation fluid. Biodegradable scintillation cocktails such as Opti-flour, Aqua-sol, Ready-Safe, etc. should be used unless there is absolutely no way to avoid using the non-aqueous scintillation cocktails. NO blood or aqueous non-scintillation vials are to be placed in the LSV containers. Stock solution vials (NEN, ICN, etc.), liquid scintillation counter standards, or vials with non-scintillation fluids are not

acceptable in LSV containers. NEVER mix dry solid or biological wastes in LSV containers.

d) **Animal carcasses** - This would consist of any animal used (during research) that contains radioactive material. This would include all parts of these animals (e.g. body, internal organs, etc.).

12.3 Solid Waste Disposal

Solid Waste includes contaminated glassware, plastic ware, paper, gels, animal carcasses, plant tissue, etc. All solid waste must be collected in appropriately labeled containers clearly indicating the radionuclide, the activity (in μCi), date of collection and name of the Authorized User, as indicated on the Monthly Inventory Record form.

Animal tissues or carcasses containing ^{3}H or ^{14}C can be disposed of without regard to their radioactivity if the levels do not exceed 0.05 μCi per gram of tissue, averaged over the weight of the entire animal. Animal tissue released in this section must be in a manner that would not permit its use either as food for humans or as animal feed. This type of waste will be handled as biomedical waste. Animals above the limit shall be referred to the RSO for disposal procedures.

Any waste containing radionuclides with half-lives of less than 120 days shall be held in storage for a minimum of 10 half-lives. After the decay period the waste shall be monitored at the container's surface and if its radioactivity is indistinguishable from background, all radiation labels shall be removed before its disposal as ordinary trash. An exception is made for radiation labels on materials that are within containers disposed of through incineration.

Disposal of other types of solid waste, which does not meet the criteria established above (^{3}H or ^{14}C of greater than 0.05μ per gram of tissue or waste with half-lives of more than 120 days) must be arranged with a licensed radioactive waste management firm through the RSO.

Clean solid wastes such as plant tissue, animal carcasses, and cage litter will be sealed in plastic bags and stored frozen until it can be removed by biomedical waste disposal.

Contaminated paper products, plastic, glass, foil, planchets, etc. shall be stored in suitable containers until sufficient quantities have been accumulated to warrant the shipment by the RSO to a licensed radioactive waste management facility.

Requests for radioactive waste pickup shall be forwarded to the RSO using Form RSO - 10 as needed.

12.4 Liquid Waste Disposal

Liquid waste includes glassware rinses or any other water miscible radiochemical. Liquid waste shall be collected separately.:

The disposal of liquid waste or contains a hazard shall be performed in the following manner: Liquid waste containing isotopes with half-lives <120 days will held for decay. After such time they will be released to the chemical waste facility. Liquid waste containing isotopes with half-lives >120 days shall be stored in suitable containers until sufficient quantities have been accumulated to warrant the shipment by the RSO to a licensed radioactive waste management facility.

12.5 Liquid Scintillation Vial Disposal

Liquid Scintillation fluid used at NSU will not contain any toluene-based cocktails.

All scintillation liquid and vials regardless of their activity will be collected and stored in suitable containers until sufficient quantities have been accumulated to warrant the shipment by the RSO to a licensed radioactive waste management facility.

12.6 Animal Carcasses and Waste

Dead animals containing radioactive material shall be prepared and stored frozen. The PI is responsible for the storage (frozen) of the animals until such time that the RSO can arrange for animal disposal through a contracted radioactive waste broker. The RSO will provide the proper labeling for the freezer.

Section 13: Decontamination

When radioactive material is in an unwanted or unplanned location, it is called contamination. This may be floors, equipment, work areas, storage areas, people or areas outside the authorized radiation use laboratory. Fortunately, most radioactive contamination and/or spills are easy to clean to background levels in a reasonable time and with reasonable cost. Contact the RSO for assistance with all decontamination procedures.

Note: The decontamination procedures will depend on the isotope, the quantity, and its use. In some situations, the water and detergent from decontaminating skin and work areas can be flushed to the sanitary sewer. In other situations, it may need to be collected. This will be addressed during training and preparing labs for isotope use to fit the needs of each radioisotope lab.

13.1 Liquid Decontamination

Concentrated liquid decontaminating agents are available from most scientific suppliers. This detergent is diluted with water and rapidly and easily cleans radioactive contamination without excessive effort. Mild wiping or scrubbing will remove most contamination using this detergent. Note that these detergents contain a carcinogen, so the Material Safety Data Sheet should be read by new radiation users so that they are aware of the hazards. In dilute liquid form, radioactive decontaminants do not present a significant hazard to handlers unless ingested or splashed in eyes. Avoid prolonged skin contact with the concentrated material.

13.2 Foam Spray Decontamination

A variety of foam spray decontamination products are available which are marketed as radioactive decontaminants. However, many other foam cleaning products accomplish decontamination just as effectively at a much lower cost; most of these are marketed in any store as bathroom or kitchen cleaning agents. Spray the foam on the contaminated areas, let sit for a few minutes, then wipe off with a dry paper towel.

13.3 Other Decontamination Agents

Many other agents will work to clean radioactive contamination that has been resistant to the above methods. Contact the RSO for assistance with difficult to remove contamination. He/she will help identify a method of decontamination which will work for your particular surface, nuclide, chemical form and location. Depending on these factors, effective solutions to the problem will be identified.

Section 14: Emergency Procedures

This section outlines basic emergency procedures. An emergency situation or accident can arise from the use, storage, or transfer of radioactive material or from the misuse or abuse of equipment that produces X-Ray radiation or other forms of ionizing radiation. This section is intended to enhance each Authorized User and worker's ability to react properly to radiation accidents.

Due to the broad scope of possible accidents at NSU, listing every step that must be followed for each type of accident would be impracticable. Instead, one must use the following basic procedures and apply them to his/her individual situation. The best advice for protection against radiation accidents is to prepare for them.

14.1 General Information

A radiation incident at NSU should be defined as any unintentional accident or any single exposure or suspected exposure in excess of 45% of the maximum allowable exposure, the ingestion of radioactive material in the form of liquid, gas, or dust in excess of limits, any radioactive material spill regardless of activity and size. If persons involved in a radiation incident are unsure as to the extent of exposure, ingestion, or magnitude of the spill, those persons shall proceed with the assumption that an overexposure (internally or externally) or major spill has occurred, unless otherwise noted. Users are required to report all radiation incidents to the RSO.

14.2 Organization and Authority

The RSO shall have responsibility for incident investigation. If preliminary findings of an incident presented to the RSC indicate there is probable cause of neglect or violation of state, federal, or local regulations or policies, the authorized user involved will be asked to attend the next RSC meeting to answer questions and present his/her account of the incident.

In the event of a major emergency situation the RSO shall have the authority to bring the situation under control. However, this RSO authority will only be used in extreme emergencies where there is immediate radiological danger to individual(s) or possible major building contamination.

The RSO has the responsibility to see that each radiation authorized user /worker knows how to:

a) Recognize a radiation emergency.
b) Prevent or confine the accident.
c) Exclude all personnel from possible risk of exposure.
d) Immediately contact his/her supervisor, the RSO, and/or other emergency personnel for assistance.

It is the responsibility of each authorized user to see that personnel working under their supervision have practical and easily understood plans for an emergency, and control of an emergency in their respective laboratory.

Each authorized user will be responsible for assisting the RSO in controlling and/or investigating the accident. Furthermore, the authorized user is responsible for assisting the victim(s) in obtaining medical attention, if necessary, as soon as practicable.

14.3 Fires, Explosions or Major Emergencies

a. Notify all persons in the area to leave at once.
b. Notify NSU Police Department, Fort Lauderdale Fire Department, EMS, and the RSO as well as other supervisory personnel. Give them the address and the location of the fire.
c. If firefighters arrive before the RSO, caution them that radioactive material is present in the area. Be ready to advise them on location, isotope(s), activity(s), type of storage, and any other information that may be needed to avoid radioactive contamination of personnel, building, or equipment.
d. The authorized user and/or workers will need to be available to evaluate or help evaluate the extent of damage to radioactive material and/or survey emergency personnel and equipment for radioactive material contamination.
e. All authorized users and workers will be required to file an incident report with the RSO.
f. MINOR FIRES - If the fire is minor (individual decision) and there are no radiation or chemical hazards involved, an authorized user or worker may attempt to put out the fire with approved fire-fighting equipment.

14.4 Accidents Involving Possible Radiation Overexposure

If a radiation overexposure has occurred, or is suspected to have occurred, proceed as follows:

a. Immediately remove affected person(s) from the area and notify the RSO.
b. Secure the area.
c. Take the affected persons(s) to the nearest emergency center immediately for clinical observation. Be sure to inform the attending medical personnel that it is a radiation accident. Be prepared to answer any questions that may arise concerning the accident or type of radiation involved.
d. Assist the RSO in obtaining all details of the incident.
e. The RSO will obtain the dosimetry readings of all involved person(s). The RSO will then forward the dosimetry readings for emergency processing.
f. Persons involved in the incident will not be permitted to work with radiological materials until exposure results have been received and the RSO has determined that exposure limits have not been exceeded.
g. The RSO will provide reports to the RSC and regulatory agencies.

14.5 Accidents Involving Significant Releases of Radioactive Materials

a. Notify all other persons in the area of the accident.
b. If possible, hold breath and close all air vents.
c. Vacate the room and seal off the area, if possible.
d. Notify the RSO immediately.
e. Secure access to the area.
f. Monitor all involved persons for contamination.

g. Assist and/or submit to any bioassay deemed necessary by the RSO, , or the State of Florida DOH.
h. Assist the RSO in hazard evaluations and decontamination procedure.

14.6 Personnel Injuries

Persons should not work with uncontained radioactive material when they have a break in the skin (cut, scrape, etc.) below the wrist. If a person is cut by an article contaminated with radioactive material the following should be used as a guide:

1. Cleanse the wound immediately by placing it under running water. If possible, retain any cotton balls, paper towels, fluids, etc. for radiological analysis. Contact the RSO as soon as practical.
2. If necessary take the person(s) for emergency treatment. Be sure to tell the attending medical personnel that radioactive material was involved in the accident.
3. Follow the necessary steps in 14.4 of this section, under the direction of the RSO

Contact the RSO before proceeding with more severe methods of decontamination.

14.7 Policies for Radioactive Spills

1. Minor Spills (< 100 microcurie level)

a. Notify other persons in the laboratory and minimize radioactive material ingestion, inhalation, etc.
b. Prevent the spread of contamination of the accident.
c. Contact the RSO.
d. Survey all persons involved, decontaminate if necessary, and release unneeded persons.
e. Begin decontamination procedures.
f. Submit incident report to the RSO.

2. Major Spills (> 100 microcuries or any amount of activity which results in personnel contamination)

a. Notify all persons in the laboratory and minimize radioactive material ingestion, inhalation, etc. Vacate the room.
b. Prevent the spread of contamination of the accident.
c. Shield the source, if possible, but only if it can be done without further contamination or without significantly increasing your radiation exposure.
d. Contact the RSO.
e. If possible, block all air vents to avoid creation of airborne contamination.
f. Close the room.
g. Survey all persons involved, and decontaminate if necessary. Do not release persons directly involved, except for emergency medical treatment. Wait for the RSO and/or the RSC to authorize release.

14.8 Loss or Theft of Radiation Equipment

Any loss or theft of radioactive material, a device containing radioactive material, or a radiation-producing device, shall be immediately reported to the RSO who will determine the extent of damage and analyze the recovery plan.

The RSO will provide required notification to the RSC and the State of Florida, Bureau of Radiation Control.

14.9 Malfunction of Radiation Producing Equipment

Any radiation device (X-Ray, etc.) believed to be defective shall be locked into a safe position and made inoperative immediately. In emergency situations the individual user, authorized user, and/or the RSO can take such action as to shield the source, deactivate the equipment, or retrieve the source.

The responsible user must restrict access to the area until the RSO arrives. The RSO will evaluate the incident thoroughly, notify the RSC in writing within 10 days and if necessary report the incident to the AGENCY within 30 days.

NOTE: Repair of any encapsulated radioactive material source IS PROHIBITED. Radiation sources involved in an accident, fire, flood, etc. MAY NOT BE USED until tested by the RSO and found to be in proper and safe operating condition.

14.10 Reporting of Radiation Incidents

It is the responsibility of the authorized user to report all incidents involving radioactive materials or radiation producing equipment in his/her approved facilities to RSO, by telephone, as soon as practicable. In addition, he/she must also report all known incidents involving his/her radioactive materials or radiation producing equipment that may occur outside his/her approved facilities.

Section 15: Animal Handling Procedures

It is the Institutional Animal Care and Use Committee's (IACUC) responsibility to pay particular attention to animal use proposals using potentially hazardous materials, including, radioactive substances, infectious microorganisms and hazardous chemicals. Each of these substances has the potential to cause harm to animals as well as those caring and working with the animals.

Some hazardous materials are strictly controlled by federal, state and local regulations. In addition to these regulations, the University has committees concerned with hazardous material use and biological material use. Nova Southeastern University has established specific safety committees composed of professional staff and faculty with expertise in handling radiological agents and biological materials. These committees include the Institutional Biosafety Committee and the Radiation Safety Committee. Chemicals are reviewed by EHS for hazardous concerns. It is the IACUC's expectation that the appropriate safety committee will review and assess potential hazards associated with animal use.

The IACUC committee must be assured that appropriate review and follow-up is being performed.

The Investigator or Authorized User is responsible for complying fully with this policy on biohazardous and radiological use involving animals.

15.1 Radioactive Materials and Radiation Sources

Review of any animal research protocol involving the use of specified radioactive materials and X-ray procedures must be coordinated between the RSO and the IACUC. It is the Investigator's responsibility to submit the appropriate forms for review to the RSO as well as to complete the appropriate section in the animal use protocol form. The PI must attach final approval from the Radiation Safety Committee to the IACUC form. Final approval of the animal use protocol is dependent on receipt of Radiation Safety Committee approval.

15.2 Hazardous Waste

Animal wastes contaminated with radioactive materials must be carefully managed to avoid human exposure or damage to the environment. Hazardous waste material must be conducted in accordance with the guidelines established by the Radiation Safety Committee and EHS. The principal investigator will assume any associated expense.

The Principal Investigator is also responsible for:

a. Conforming to all regulations established by the Institutional Animal Care and Use Committee.
b. Notifying the Animal Care Facility that animals containing radioisotopes will be housed in their facilities.
c. Notifying the Radiation Safety Officer that animals containing radioisotopes will be housed in the Animal Care Facility and providing any additional information as requested.

d. Insure that cages are decontaminated before returning them to the Animal Control Facility for cleaning.
e. Dispose of the carcass and bedding in accordance with the radioactive waste program.

Procedures for handling hazardous animal waste:

a) All work shall be performed in rooms specified by the RSO. These rooms must be marked by a Caution Radioactive Material label bearing the radioactive symbol.
b) After a radioactive material has been introduced into an animal, its cage and equipment shall be marked by caution tape bearing the radioactive symbol. The name of the investigator, the isotope used, the quantity of radioactive material injected (in microcuries), the date of injection, and the route of injection shall also be noted on the cage. The Institutional Animal Care and Use Committee in conference with the RSO will review the procedures involving the use of radioactive materials in animals.
c) After radioactive materials have been introduced into experimental animals, each animal shall be identified. The cage, bedding, wastes, and in some cases the rack and the room must be recorded and treated as radioactive. This implies considerable care in the handling and disposal of equipment, waste, and animals.
d) It is the authorized user's responsibility to have all radioactive waste (bedding, excreta, etc.) collected in approved plastic containers and checked for contamination. If contaminated, the waste is delivered to the Radiation Safety Officer for disposal. Radioactive animal cadavers are to be tightly wrapped and placed in a freezer designated by the RSO. Do not place animal cadavers directly into the waste disposal barrel.

Section 16: Records

Under the terms of the University's authorizations to use radiation sources, EHS is charged with maintaining portal-to-portal surveillance of all radiation sources on the campus. In order to facilitate this surveillance and to insure that a high awareness of the rules and regulations governing the safe use of radiation sources is maintained, it is required that certain records and reference materials be maintained. Records are to be maintained by the Authorized User and EHS for a period of three years unless advised otherwise.

These records and references include, but are not limited to, the following:

a) The University's current Radiation Safety Plan. All other versions must be saved.

b) Copies of the RSO forms submitted to EHS.

c) Radioactive Materials Monthly Inventory Record forms.

d) Radiation and contamination surveys performed by the Authorized User and EHS.

e) Radioactive Waste Disposal records.

Section 17: X-Ray Safety

All matter in our environment is made of atoms. Most atoms we encounter on Earth are stable. Some atoms, however, are unstable, giving off energy in the form of radiation in order to reach a stable state. These atoms are said to be radioactive. An example is the radionuclide, Carbon-14, produced in the atmosphere when cosmic rays interact with stable nitrogen atoms. When a Carbon-14 atom undergoes radioactive decay, it gives off radiation in the form of a beta particle and then becomes a stable nitrogen atom once again. The existence of Carbon-14 in all living things enables archaeologists to date ancient artifacts.

Radiation can only be detected by specially designed instruments. Radiation may pass through an object, but it may be absorbed and cause changes at the site of absorption. Radiation is known to cause cancer and birth defects in animals and humans. The risk of radiation damage is related to the amount of radiation absorbed by an individual. With the amounts of radiation encountered by employees of the NSU, the risk is very small.

There are small amounts of naturally occurring radioactive substances in soil, rocks, plants, animals, and in our own bodies, all of which give off radiation. Large amounts of radiation are present in outer space and a small portion of this radiation penetrates the atmosphere. This low level of naturally occurring radiation is known as background radiation.

Radiation is beneficial in medicine because it allows for the imaging and non-surgical treatment of internal structures and diseases. However radiation may produce harmful biological effects. Observations of exposed human populations and animal experimentation indicate that exposure to low levels of radiation over a period of years may lead to an increase in the incidence of cancer and leukemia. Exposures to high levels of radiation produce the same effects faster and may also cause hair loss, skin burns, radiation sickness or even death. Radiation may also increase the risk of genetic abnormalities.

17.1 Radiation Protection at NSU

To minimize the biological effects of radiation, special rules and regulations are set forth for individuals occupationally exposed to radiation. The amount of radiation received by persons exposed occupationally should not exceed the dosages specified in the State of Florida Regulations, Florida Administrative Code 64E-5, 701-5, 704.

There is, in general, minimal external radiation hazard to personnel from procedures involving radiation. Depending on your specific job duties, you may or may not be classified as a “radiation worker” and may or may not be required to wear personnel monitoring devices. All x-ray equipment operators are considered “radiation workers” and most require personnel monitoring. The need for personnel monitoring is determined by the likelihood of receiving exposures in excess of certain regulatory limits. Adherence to guidelines contained in this manual will help all x-ray equipment operators and radiology staff members keep their exposures as low as reasonably achievable (ALARA), and for most staff members should reduce radiation exposures to levels allowable for individual members of public or in some cases, to levels indistinguishable from natural background.

Radiation protection support services are provided the EHS Office. These services include the oversight and administration of the personnel monitoring program, area surveys and x-ray equipment inspections, and in-service training of NSU workers.

17.2 Radiation Producing Equipment

In *diagnostic radiography*, x-rays are produced when high-energy electrons collide with a metal target in an x-ray tube. X-rays are only produced when the machine is activated. The patient does not become radioactive.

In *diagnostic fluoroscopy*, x-ray images are viewed on a video monitor rather than on film. Fluoroscopy procedures are the largest source of occupational radiation exposure in medicine. Fluoroscopy is used to study moving structures, and to assess positioning during surgical and radiographic procedures. The portable fluoroscopy unit is often referred to as a "c-arm." All x-ray machines are "registered" with the state radiation protection regulatory agency, the Bureau of Radiation Control (BRC).

In *radiation therapy*, linear accelerators (powerful x-ray machines) are used for the treatment of cancer. The energy of the radiation produced by these units is 10 to 100 times that of a diagnostic x-ray machine. Linear accelerators may treat with either x-rays or electrons.

17.3 Typical Exposure Levels During X-ray Examinations

An individual located four feet from the patient's bed at the time that radiographic exposure using a 14 x 17 image receptor is made may typically receive about 0.010 millirem. To receive 500 millirem, one would have to remain at that distance for 50,000 x-ray exposures. An individual located four feet from a patient undergoing fluoroscopy may typically receive about 0.50 millirems per minute while the machine is "on". To receive 500 millirem, one would have to be in the location for 15-20 hours with the machine operating. Since radiation decreases rapidly with distance, the further one is from the patient during the actual x-ray examination, the smaller the exposure.

17.4 Radiation and Risk

Effects of large doses of radiation are well-documented and understood from the research of groups including atomic bomb survivors, radiation accident victims, radiation therapy patients, and early radiation researchers. The effects of the very low doses of radiation expected among workers in the university setting are not, however, so well understood. When a large dose of radiation is increased to an even larger dose, the adverse effects become greater or more prevalent. This dose vs. effect relationship can be thought of as linear, with confirmed and documented effects beginning at a certain "threshold" level of radiation dose.

But since this "threshold" level is far greater than any allowable occupational dose, how is the risk of occupational radiation exposure assessed? Even though the effects of very low doses of radiation are truly not known, health physicists "extend" what is known about higher doses of radiation down to "zero" dose. In other words, any radiation dose is assumed to have some effect. Most scientists believe that this is a conservative model of the risk.

Consider that for very low doses of radiation the effect of most concern is cancer. If every member of a population of 1 million were to receive 10 millirem of radiation (average film chest x-ray), it is possible that 5 additional cancer deaths would be observed. Remember however, that out of this population of 1 million, about 200,000 (20%) will die of cancer, making these few additional cancer deaths statistically impossible to detect. Additionally, according to the Biological Effects of Ionizing Radiation (BEIR) committee, the risk of cancer death is 0.08% per rem for doses received rapidly (acute) and might be 2 times (0.04% per rem) less than that for doses received over a long period of time (chronic).

It's important to keep in mind that all activities carry some element of risk. For example, flying in an airplane, driving a car, smoking cigarettes, eating certain foods, and drinking alcoholic beverages are everyday activities that carry some risk. Many of us are willing to accept the risk from these activities.

17.5 Fetal Protection Policy

Recent studies have shown that the risk of childhood leukemia and other cancers increases if the mother experienced a significant radiation exposure during pregnancy. The National Academy of Sciences has reported that the incidence of leukemia among children from birth to 10 years of age could rise from 3.7 cases in 10,000 children to 5.6 cases in 10,000 children if the children were exposed to 1 rem (1000 millirems) of radiation before birth (a rem is a measure of radiation dose in the human body). The Academy has also estimated that an equal number of other types of cancers could result from this level of radiation. Although other studies have shown a much smaller effect from radiation, each woman should be aware of any possible risk so that she can take steps she thinks are appropriate to protect her offspring.

NSU has adopted a policy to protect the fetus/embryo of pregnant employees exposed to ionizing radiation in their work. The State of Florida radiation protection regulations limit the occupational dose to pregnant women to 500 millirems over the course of the pregnancy if the worker declares her pregnancy in writing to the employer. This value is one-tenth of the permissible annual exposure established for adults. To help put this in perspective, the average annual dose from natural radiation sources is approximately 300 millirem.

If an employee decides to declare her pregnancy, she should notify her supervisor who will arrange for her to meet with the Radiation Safety Officer to discuss possible precautions to limit radiation exposure. Pregnancy Declaration forms are available from Radiation Safety Officer. The Radiation Safety Officer will review work assignments and radiation exposure history, and may recommend limitations in work assignment if necessary. Dosimeters will be assigned, with radiation exposures to be reviewed monthly. If radioactive materials are used, the employee may also be placed on a periodic bioassay program.

17.6 Operator Qualifications and Indication for Use

All diagnostic equipment shall be used under the direction or supervision of a qualified physician. Only qualified physicians, engineering and physics staff members, and those technologists who

are ARRT-registered, registry eligible, or in-training for ARRT registration shall be authorized to make radiographic or fluoroscopic exposures.

Dental x-ray equipment shall only be used under the direction or supervision of a qualified physician or dentist. Only qualified physicians, dentists, dental hygienists, technicians, engineering and physics staff members, and radiologic technologists shall be authorized to make dental x-ray exposures.

Examinations involving radiation should be requested by the physician specifically to produce information relating to the patient's clinical condition. The request should reflect the physician's knowledge of the clinical condition. The examination should not be repeated merely for the physician's convenience. It should be kept in mind that not exposing the patient gives the largest dose reduction.

17.7 Guidelines for Safe Operation of X-ray Equipment

a) Personnel monitoring devices should always be worn when working with radiographic/fluoroscopic equipment.
    i. The devices worn should be those issued for the current time period and should be worn at the collar for those workers who wear only one device.
    ii. For those workers who have been issued two personnel monitoring devices, one should be worn at the collar and the other at the waist under the lead apron.
    iii. Those workers wearing film badges should ensure that the film has been properly inserted into the badge holder.
b) Only persons whose presence is necessary should be in the radiographic or fluoroscopic room during exposure. All such persons who are subject to direct scatter radiation shall be protected by aprons or whole body protective barriers of not less than 0.25 mm lead equivalent.
    i. A lead apron of 0.25 mm lead equivalence will reduce scattered x-rays by 95%. Additionally, the shielding integrity of protective shielding devices must be evaluated on an annual basis.
c) Mechanical supporting or restraining devices shall be used when a patient or image receptor must be held in position for radiography or fluoroscopy.
    i. If a patient must be held by an individual, that individual shall be protected with appropriate shielding devices of at least 0.25 mm lead equivalence for whole body protection and at least 0.5 mm lead equivalence for any part of the holder’s body that is exposed to the primary x-ray beam.
    ii. Preferably, the individual holding the patient should be a member of the patient's family.
    iii. No individual shall be used routinely to hold patients or image receptors. In general, x-ray equipment operators should not hold patients during x-ray exams. However, it may be necessary under exceptional circumstances when there is no alternative.
d) The exposure to the patient should be kept to the practical minimum consistent with clinical objectives.

   i. Technique charts indicating that set of factors (kVp, mAs) which normally yield the optimal exposure for a body part of specific size and orientation should be available for each x-ray tube capable of making radiographic exposures.
   ii. Technique charts should be used whenever applicable.

e) The x-ray beam should always be collimated to the smallest area consistent with clinical requirements and should always be aligned accurately with the patient and image receptor.
f) Mobile equipment should be used only for examinations where it is impractical to transfer patients to permanent radiographic installations.
g) Gonadal shielding of not less than 0.5 mm of lead equivalent shall be used for potentially procreative patients during radiographic procedures in which the gonads are in the direct, or useful beam, except for cases in which the clinical objectives of the examination would be compromised.
   i. Gonadal shielding shall never be used as a substitute for careful patient positioning and adequate limitation of the beam.
h) The smallest practical field sizes and shortest exposure times should be used. (Exception: Long exposure times may be required for breathing technique studies.)
   i. The possibilities of reducing dose by techniques utilizing high tube potential (kVp) and low current (mA) should be considered, as long as image quality is not compromised.
i) The operator must stand behind the barrier provided for his/her protection during radiographic exposures at permanent radiographic installations.
   i. An exemption to this requirement has been granted for the Cysto suite in which the operator remains in the room during radiographic exposures and wears a lead apron. Operators of DEXA equipment should remain at least 6 feet from the patient during exposures, or as far away as practical due to room space limitations.
   ii. Operators should stand as far as possible (at least 6 feet) from the patient when operating mobile equipment.
j) Exposures are to be made with doors to the x-ray room closed. Exposures should be avoided in these areas when individuals are in or near the doorways of these areas.
k) Each mobile radiographic equipment operator, prior to making an exposure, should ask anyone within 6 feet of the x-ray tube and/or patient being radiographed to move further away until the exposure is complete.
   i. Those persons who must remain within 6 feet of the patient and/or x-ray tube must be protected by whole body aprons or barriers of at least 0.25 mm lead equivalence. The operator shall give an audible warning before the exposure is made.
l) The exposure rate used in fluoroscopy should be as low as is consistent with the fluoroscopic requirements and should not normally exceed 10 R/min (measured in air) at the position where the beam enters the patient.
   i. It is usually best to operate fluoroscopic machines with the “automatic brightness system” engaged to optimize performance and minimize patient dose.
m) Fluoroscopy should not be used as a substitute for radiography and should be reserved for the study of dynamics or spatial relationships or for guidance in spot-film recording of critical details.

n) Medical fluoroscopy should be performed only by or under the immediate supervision of physicians properly trained in fluoroscopic procedures.
o) The hand of the fluoroscopist should not be placed in the useful beam unless the beam is attenuated by the patient and a protective glove of at least 0.5 mm lead equivalent.
p) In cineradiography, special care should be taken to limit patient exposure when, as is often the case, tube currents and potentials employed are higher than those normally used in fluoroscopy.
q) Film processing materials and techniques should be those recommended by the x-ray film manufacturer or those otherwise tested to ensure maximum information content of the developed x-ray film. Quality control methods are employed at NSU to ensure optimal results.

17.8 Special Considerations

1. Pregnant or Potentially-Pregnant Patients

Special precautions, consistent with clinical needs, shall be taken to minimize exposure of the embryo or fetus in patients known to be or suspected of being pregnant. It is the responsibility of the referring physician to determine the pregnancy status of patients of childbearing age, and to write a note in the chart describing the indication for the study and confirming that this was discussed with the patient. Exceptions to this include any study involving body parts above the abdomen or below the hips.

When the x-ray procedure does not include the abdomen or pelvis of the pregnant or potentially-pregnant patient, the abdominal region should be shielded with at least 0.25 mm lead equivalence whenever feasible, and the examination performed without regard to pregnancy.

When the x-ray procedure includes the abdominal region of the pregnant or potentially-pregnant patient, the examination shall not be performed without approval from the physician responsible for the procedure involving radiation. Written informed consent should be obtained for all procedures involving direct exposure of the conceptus and/or whenever conceptus dose is likely to exceed 1 rem and shall be obtained whenever dose to the conceptus is likely to exceed 5 rem. Consent forms are available in English and Spanish. Procedures involving the abdomen or pelvis with the conceptus in the field of view that are likely to deliver a conceptus dose greater than 1 rem include, but are not limited to, CT, fluoroscopy in excess of 1 minute, and radiographic procedures requiring multiple imaging (>3) of the conceptus region.

Although it is the responsibility of the referring physician to determine pregnancy status, those operating diagnostic x-ray equipment shall ask all patients of childbearing age whether or not they are pregnant and the date of their last menstrual period. This information is to be recorded prior to the procedure. When pregnancy status is unclear, or when the date of the last menstrual period is greater than two weeks (14 days), a urine pregnancy test must be performed to exclude pregnancy, unless the delay necessary to perform the pregnancy test would jeopardize the patient's health.

Radiation exposure must be used judiciously and kept to a minimum, and imaging techniques not involving radiation should be considered. The imaging techniques used, such as fluoroscopic time, kVp and mA, as well as the number of images taken and the abdominal thickness measurements

are to be recorded. A radiation physicist should be contacted to assist with dose estimates. A formal dose calculation will be performed for procedures that are likely to deliver a conceptus dose in excess of 15 rem.

2. Fluoroscopically-Guided Interventional Procedures

A number of fluoroscopically-guided interventional procedures are in use that have the potential for extended fluoroscopic time. The cumulative radiation entrance dose from these procedures can be sufficient to induce skin injuries. A thorough equipment quality control program can minimize or prevent these injuries. Including skin injury as one of the procedure risks in the patient consent form can inform the patient, prevent undue concern and promote early injury reaction and awareness.

17.9 Facility Design

Each radiographic and fluoroscopic x-ray tube in NSU is tested annually for compliance with performance and use criteria as specified by state and federal regulations. Exposures and exposure rates to which patients are normally subjected are determined from these tests.

Each radiographic and fluoroscopic facility is designed such that no individual member of the public or a person who is occupationally exposed will receive an annual radiation dose in excess of the annual dose limits as specified in state regulations.

17.10 X-ray Equipment Administrative Policy

It is the intent of this policy to assure that all ionizing radiation producing equipment be safe and that all such equipment meets applicable Federal and State standards, following receipt and installation at within NSU system.

1. Construction or Renovation of Facilities to House x-ray Equipment.

Any renovations, alterations to or construction of facilities for the use of ionizing radiation producing equipment, shall be designed and constructed to meet all appropriate radiation safety standards. The standards are defined by the State of Florida and interpreted by the Radiation Safety Officer (RSO). The RSO shall be included in planning meetings, mailings, and plan reviews in the early stage of applicable projects. All final construction drawings for such facilities or alterations shall be reviewed by the RSO prior to release for bid and a shielding plan review documented and filed with the state regulatory agency. In addition, any variations from the approved shielding plan, during construction, must be reviewed by the RSO. The RSO will
inspect the shielding assembly during construction for proper installation. A full radiation safety acceptance survey will be performed on the completed facility.

2. Registration of Ionizing Radiation Producing Equipment.

All ionizing radiation producing equipment under the jurisdiction of NSU system must be tested, accepted and registered with the State of Florida regulatory agency by the RSO within 30 days of initial operation. The receipt of equipment of this type shall require notification to the RSO.

3. X-ray Equipment, Relocation, Storage, or Disposal.

Any activity (other than routine maintenance), regarding the modification, relocation, storage or disposal of ionizing radiation producing equipment shall be reviewed by the RSO. Upon completion of the activity, the RSO shall make the appropriate determinations to assure safe operation of modified or relocated equipment. The RSO must also be notified of equipment that is to be surplused, resold or dismantled to maintain a current x-ray equipment registration with the State of Florida regulatory agency.

4. Responsibility of Reporting to the RSO

To assure proper communications with the RSO concerning the above issues, the following responsibilities are designated:

a) The RSO, or designee, should attend the diagnostic radiology QC meetings.
b) The Electrical Engineering section of the Facilities Department is responsible for notifying the Radiation Safety Office of any renovations or new construction that will contain ionizing radiation producing equipment.
c) Each department that uses ionizing radiation is responsible for identifying and designating a contact person who, in turn, is responsible for informing the RSO of any activities within their department involving radiation producing equipment. Such activities include purchases of new equipment, modifications, relocations, evaluating equipment on loan, and disposal of equipment.

Important!

Report any unusual or unsafe condition involving sources of radiation to the RSO. Any non-emergency questions during normal duty hours may be directed either to the RSO or to the EHS Office.

For information about radiation exposure during pregnancy, call the RSO. Use Time, Distance and Shielding, as well as disposable gloves and lab coats to keep your radiation exposure **A**s **L**ow **A**s **R**easonably **A**chievable.

The NSU Radioactive Materials licenses, x-ray registrations, regulations, inspection reports and exposure reports are available for review in the EHS Office.

Section 18: Laser Safety

The purpose of this section is to ensure the safe use of lasers at NSU by identifying hazards, providing medical surveillance, and providing laser safety training for individuals using lasers. To achieve this goal, the University has adopted the American National Standard for the Safe Use of Lasers, ANSIZ136.1-1993. ANSI Z136.1-1993 is recognized as a minimum standard for laser safety. A copy of the NIU Laser Safety Manual must be available in each department using Class 3b or Class 4 lasers. A copy of ANSI 2136.1-1993 or later applicable edition is available in the Radiation Safety office.

Most lasers are capable of causing eye injury to anyone who looks directly into the beam or specular reflections. In addition, diffuse reflection of a high-power laser beams can burn exposed skin, ignite flammable materials, and activate toxic chemicals that release hazardous fumes, gases, debris, and radiation. The equipment and optical apparatus required to produce the lasing action and control and direct the laser beam also introduce additional hazards associated with water, high voltage, high pressure, cryogenics, noise, radiation, and toxic gases.

18.1 Responsibilities

1. The Laser Safety Committee

The Laser Safety Committee is responsible for the following:

a) Develop and promulgate policies and procedures regarding laser safety within the university;
b) Review and grant permission for, or disapprove, the use of laser equipment of Class 3 or higher for experimental, routine, or non-routine uses within the university from the standpoint of health and safety of experimenters, students, and staff, and the general public;
c) Recommend candidates to the Vice Provost for Research for the position of University Laser Safety Officer;
d) Outline the duties of the Laser Safety Officer;
e) Insure compliance with laser safety standards, including federal and state regulations, and non-regulatory standards as outlined in the American National Standards Institute (ANSI) Z136 series of laser safety standards;
f) Review annual reports from the LSO regarding personnel training records, laser hazard control measures, laser safety inspections, and other matters concerning use and operational hazards of lasers.
g) Investigate alleged infractions of safety rules or improper use of laser equipment brought to their attention by the radiation safety officer or other responsible personnel; and recommend remedial action to correct such infractions.

2. The Laser Safety Officer

The Laser Safety Office (LSO) or his/her representative will:

a) Maintain inventory of all Class 3b and Class 4 lasers. Classify or verify classification if necessary.
b) Be responsible for hazard evaluation of laser work areas, including the establishment of Nominal Hazard Zones.
c) Approve standard operating procedures, alignment procedures and other control measures.
d) Provide consultative services on evaluation and control of laser hazards and worker training programs.
e) Inspect at least annually all Class 3b and Class 4 lasers for compliance with NSU Laser Safety Program. Ensure any required corrective action is taken.
f) Suspend, restrict or terminate the operation of a laser or laser system without adequate hazard controls, and advise Laser Safety Committee of such action.
g) Approve wording on area signs and equipment labels.
h) Maintain records required by various regulatory bodies. Ensure records are maintained of medical examinations and training has been provided.
i) Investigate incidents involving potentially harmful laser exposures.

3. Investigators or Supervisor

Principle Investigators and supervisors are responsible for:

a) The immediate supervision of lasers in the laboratory.
b) Providing, implementing, and enforcing the safety recommendations and requirements prescribed in this program.
c) Classifying and labeling all of their lasers.
d) Completing a Laser Registration Form and sending it to the Laser Safety Officer.
e) Training all employees who work with and around Class 3b, and 4 lasers in the safe use of lasers. This training has to be documented.
f) Registering for the Medical Surveillance program for users of Class 3b and Class 4 lasers.
g) Notifying the LSO immediately in the event of an exposure to a Class 3b or Class 4 laser.

4. Laser Operators

Laser Operators are responsible for:

a) Following laboratory alignment, operational, safety, and maintenance Standard Operating
b) Procedures. Reading additional safety instructions in laser equipment operators manuals.
c) Keeping the Investigator or supervisor fully informed of any departure from established safety procedures. This includes notification of an exposure incident.
d) Registering for the Medical Surveillance program for users of Class 3b and Class 4 lasers.

18.2 Personnel Training and Qualification

All staff and students operating lasers are required to read the Laser Safety Manual and receive initial laser safety training.

Only a qualified and authorized person is permitted to operate a laser. The Investigator or supervisor determines the employee's operational qualification from departmental or technical training or other acceptable learning experience. Before operating a Class 3b or Class 4 laser a person must:

a) Review the Laser Safety Manual.
b) Receive from the lab supervisor or Principle Investigator a thorough review of the laser equipment to be used and the administrative, alignment and standard operating procedures (SOP's).
c) Review the operating and safety instructions furnished by the manufacturer.

18.3 Medical Surveillance

Individuals operating Class 1, 2, and 3a lasers are exempt from eye exams. Laser operators or individuals who will work in areas where there may be exposure to laser radiation from a Class 3b or Class 4 laser are required to have a baseline eye examination within two years prior to using the laser.

An eye exam is required in the event of exposure or suspected exposure incident. An examination is not required when an individual laser user terminates his or her work in a laser laboratory unless the employee has had a known laser injury to the eye.

18.4 Exposure Incident

In the event of exposure, the following procedures apply:

a) If an exposure incident occurs, the LSO must be notified by the Principal Investigator or the person operating the laser.
b) If the incident causes an injury or could potentially have caused an injury, the person or persons who have received an exposure should inform their supervisor and have an eye exam performed. That person can contact the LSO for a doctor's appointment if they so choose.
c) Laser Safety personnel will conduct an investigation, and an incident report will be written.

Maximum Permissible Exposure (MPE): The level of laser radiation to which a person may be exposed without hazardous effect or adverse biological changes in the eye or skin. The criteria for MPE for the eye and skin are detailed in Section 8 of ANSI Z136.1-1993.

18.5 Laser Hazard Analysis

Before appropriate controls can be selected and implemented, laser radiation hazards must be identified and evaluated.

Types of hazards include:

a) **Eye**: Acute exposure of the eye to lasers of certain wavelengths and power can cause corneal or retinal burns (or both). Chronic exposure to excessive levels may cause corneal or lenticular opacities (cataracts) or retinal injury.
b) **Skin:** Acute exposure to high levels of optical radiation may cause skin burns; while carcinogenesis may occur for ultraviolet and near ultraviolet wavelengths.
c) **Chemical:** Some lasers require hazardous or toxic substances to operate (i.e., chemical dye, Excimer lasers).
d) **Electric shock:** Most lasers produce high voltages that can be lethal.
e) **Fire hazards:** The solvents used in dye lasers are flammable. High voltage pulse or flash lamps may cause ignition. Flammable materials may be ignited by direct beams or specular reflections from high power continuous wave (CW) infrared lasers.
f) **Water Hazards:** In general, lasers are water-cooled, so flooding is a possibility. Hose connections should be checked regularly.

Lasers and laser systems are grouped according to their capacity to produce injury, and specific controls are then described for each group. Lasers manufactured after August 1, 1976, are classified and labeled by the manufacturer. Information on the label must include class, the maximum output power, the pulsed duration (if pulsed), and the laser medium or emitted wavelengths.

18.6 Laser Classification

Lasers are generally classified and controlled according to the following criteria:

Class 1: Low-power lasers and laser systems that cannot emit laser radiation levels greater than the Maximum Permissible Exposure (MPE). Class 1 lasers and laser systems are incapable of causing eye damage and are therefore exempt from any control measures.

Class 2: Visible, low power lasers or laser systems that are incapable of causing eye damage unless they are viewed directly for an extended period (greater than 1000 seconds).

Class 3: Medium-power lasers and laser systems capable of causing eye damage with short duration (<0.25 s) exposures to the direct or specularly reflected beam. Includes Class 3a and 3b lasers.

- **Class 3a**: Lasers or laser systems that normally would not produce a hazard if viewed for only momentary periods with the unaided eye. They may present a hazard if viewed using collecting optics.
- **Class 3b**: Laser or laser systems that can produce a hazard if viewed directly. This includes intrabeam viewing or specular reflections.

Class 4: High power lasers and laser systems capable of causing severe eye damage with short-duration (<0.25 s) exposures to the direct, specularly reflected, or diffusely reflected beam. Class 4 lasers and laser systems are also capable of causing severe skin damage and igniting flammable and combustible materials.

18.7 General Laser Safety Recommendations and Requirements

1. Eye Protection: Principal Investigators or staff who operate or supervise the operation of a laser are responsible for determining the need for laser eye protection for a particular laser. If required, eye protection will be provided by the supervisor for staff and visitors to the area. The booklet "Guide for Selection of Laser Eye Protection" produced by the Laser Institute of America may provide assistance in eyewear selection. Check with your Principal Investigator or the LSO for a copy.
2. The minimum laser radiant energy or laser power level required for the application should always be used.
3. Beam Control: To minimize direct eye exposure, observe these precautions:
   a. Do not intentionally look directly into the laser beam or at a specular reflection, regardless of its power.
   b. Terminate the beam path at the end of its useful path.
   c. Locate the beam path at a point other than eye level when standing or when sitting at a desk.
   d. Orient the laser so that the beam is not directed toward entry doors or aisles.
   e. Minimize specular reflections.
   f. Securely mount the laser system on a stable platform to maintain the beam in a fixed position during operation and limit beam traverse during adjustments.
   g. Confine primary beams and dangerous reflections to the optical table.
   h. Clearly identify beam paths and ensure that they do not cross populated areas or traffic paths.
   i. When the beam path is not totally enclosed, locate the laser system so that the beam will be outside the normal eye-level range, which is between 1.2 to 2 meters from the floor. A beam path that exits from a controlled area must be enclosed where the beam irradiance exceeds the MPE.

18.8 Additional Controls for Class 1 and Class 2 Lasers

1. If the laser has not been labeled by the manufacturer, attach a label on the laser with its classification and relevant warning information. Contact the LSO office for assistance. *Refer to the ANSI Z136.1-1993 for further guidance on control measures for various classifications of lasers.*

18.9 Additional Controls for Class 3b and 4 Lasers

1. All Principal Investigators are required to write standard operating procedures (SOP) for all laser operations involving Class 3b and Class 4 lasers detailing alignment, operation, safety and maintenance procedures. The SOP should be posted or attached to the inside surface of the lab door.
2. Other unusual operating circumstances may require additional procedures. Contact the Laser Safety Officer for assistance.
3. A log must be maintained showing periods of use, service, maintenance and incidents. Required monthly interlock checks should also be included in this log.

4. Labels: A laser classification label must be conspicuously affixed to the laser housing.
5. Warning Signs: Each entrance must be posted with a danger sign in accordance with ANSI Z136.1-1993.
6. Warning Devices: Entrance to laboratories with a Class 4 laser shall have a lighted warning sign that is fail-safe interlocked with the laser, to activate when the laser is energized. The device must be tested monthly.
7. Safety Interlocks for Class 4
    a. All protective enclosures that surround laser devices and high-voltage electrical sources must also be equipped with interlocks to prevent operation of the equipment when enclosures are not in place.
    b. Interlocks must be tested monthly to ensure that they are operational. A written record must be kept of each test in the log book.
    c. Interlocks must be designed so that after they are actuated, the capacitor banks, shutters, or power supplies cannot be re-energized except by manually resetting the system.
8. The responsible individual in a laser area controlled by a warning light is permitted to momentarily override (bypass) interlocks to allow access of authorized persons if all of the following conditions are met:
    a. There is no laser radiation hazard at the point of entry.
    b. The necessary protective devices are worn by the personnel entering the area.
    c. An interlock bypass circuit is designed into the interlock control system.
    d. This bypass circuit must only be operated from inside the interlocked area. It must delay no more than 15 seconds before shutting down the system.
9. If interlocks are not feasible, the Investigator or supervisor may consider the use of alarms, voice warnings, danger lights, door locks, key cards, or extensive security. The Laser Safety Officer and the Laser Safety Committee must be consulted in choosing alternatives to interlocks.
10. Laser laboratories and controlled areas must be designed so that personnel can enter and leave under emergency conditions.
11. Lasers must have a master switch with a key or coded access that prevents use once the key has been removed or a code has been entered. The key must not be left in the control panel when the laser is not in use.
12. Laser Activation Warning Systems: An alarm, a warning light, or a verbal "countdown" command must be used during activation and start up.
13. Lasers must have a permanently attached beam stop or attenuator and emission delays.
14. Laser controlled areas shall be established which have limited access and shielding sufficient to contain or direct scattered radiation. Access to the area during laser operation requires the permission of the responsible operator.
15. Class 3b and 4 infrared laser beams with a wavelength greater than or equal to 710 nm must be terminated with fire resistant material.
16. Securely fasten all mirrors, prisms, beam stops, etc. in the beam path. Ensure that the laser is also securely fastened.
17. Circuit breakers must be identified for each laser.
18. Beam Enclosure: The entire beam path of Class 4 lasers, including the target area, should be surrounded by an enclosure equipped with interlocks that prevent operation of the laser system unless the enclosure is properly secured. When total

enclosure of the laser beam path is not practical, both the non-enclosed laser beam and any strong reflections must be terminated at the end of their useful path using such devices as backstops, shields or beam traps.

19. Reflection Control
    a. Materials that diffusely reflect laser radiation must be used in place of specularly reflective surfaces wherever possible.
    b. To minimize personnel exposure, specularly reflecting surfaces that are needed for beam path control should be enclosed or shielded.
20. Invisible Beams
    Ultraviolet (UV) and infrared (IR) lasers that emit invisible beams require several additional controls:
    a. Visual or audible beam-warning devices must be installed in areas where personnel may be exposed to radiation in excess of the MPE. These warning devices must be clearly identified and visible from all areas of potential exposure.
    b. Shielding must be installed that will attenuate UV radiation to levels below the MPE for the wavelength being used.
    c. Hazardous concentrations of by-products formed by the reaction of intense UV radiation with materials in the area must be controlled.
    d. IR beam enclosures and backstops must be fabricated of IR-absorbent material and must also be fire-resistant.
21. Beam Mapping
    Controlled laser areas must be surveyed by the user both initially and when beam path changes are made to locate and identify direct and reflected beams that exceed the MPE. Shielding may be required to limit unwanted radiation.
22. Direct Viewing
    Personnel must never look directly into any laser beam.
23. Alignment
    a. High power laser optical systems must never be aligned by direct beam viewing if the radiant exposure or irradiance exceeds the MPE.
    b. Use low-power lasers, diffuse reflectors, image-retaining screens, exposed Polaroid film, and other devices that will minimize eye exposure.
24. Optical Viewing Aids
    Using optical systems such as cameras, telescopes, microscopes, etc., to view laser beams may increase the eye hazard. Therefore, all collecting optics must incorporate suitable means (such as interlocks, filters, or attenuators) to prevent eye exposures above the MPE.
25. Protective Equipment
    a. Laser protective eye wear shall be worn whenever MPE levels may be exceeded. However, it is good practice to always wear eye protection when lasers are in use.
    b. In general, eye wear provides protection over a narrow range of the laser spectrum. Eye wear designed for protection at one wavelength may afford little or no protection at another wavelength.
    c. Consult eye wear manufacturers and the LSO for proper selection of protective eye wear Laser protective eye wear must be approved by the American National Standards Institute (ANSI) and clearly labeled with optical densities and wavelengths for which protection is afforded. Eye wear must be inspected periodically by the user

for pitting and cracking of the attenuating material, and for mechanical integrity and light leaks in the frame.
   d. Protection for the skin may be afforded through the use of clothing to cover normally exposed skin areas.
   e. Protective equipment is no substitute for common sense and the use of good safety practices.
26. Unattended Equipment
   a. When lasers are to be left unattended, de-energize the power supplies or capacitor banks and remove the keys from power switches or master interlocks to prevent unauthorized activation of the equipment.
   b. The operation of unattended lasers is only allowed when a specific SOP has been written and approved by the Principal Investigator and the Laser Safety Committee.
27. Temporary Installations
   a. Occasionally, it may be necessary to remove protective enclosures or override equipment interlocks or other safety devices for service adjustments, maintenance, special training exercises, etc.
   b. In these instances, a temporary controlled laser area must be set up. Specific methods for handling situations of this type must be described in the SOP.
   c. Because the area will not have all the standard safety features, the SOP must describe provisions for protecting personnel who could potentially be exposed.
   d. When the entire beam path is not fully enclosed, restrict access into the area to persons wearing proper protective equipment. Make sure that all optical paths from the restricted access area are adequately covered to prevent escape of laser radiation greater than the MPE for the eye.
28. Refer to the ANSI Z136.1-1993 and Table 10 of this manual for further guidance on control measures for various classifications of lasers.

18.10 Converting to a Class 1 Enclosed Laser

Any laser or laser system can be converted to a Class 1 enclosed laser by including all of the following controls in the laser system design. These controls will effectively enclose the laser, thus preventing personnel contact with emitted radiation while permitting unrestricted access into the area.

Approval must be obtained from the Laser Safety Committee in order to convert a Class 3b or Class 4 laser to a Class 1 enclosed laser.

1. Protective Housing
   a. House the laser system within a protective enclosure to prevent escape of laser radiation above the MPE.
   b. The protective housing must prevent personnel access to the laser system during normal operations.
   c. Personnel entering the enclosure to perform maintenance or adjustment tasks must be made aware of the higher risk laser class.
2. Safety Interlocks
   a. Install safety interlocks wherever the protective enclosure can be opened, removed or displaced.

   b. When activated, these interlocks must prevent a beam with a radiant energy above the MPE from leaving the laser or laser system.
   c. Service adjustments or maintenance work performed on the laser system must not render the interlocks inoperative or cause exposure levels outside the enclosure to exceed the MPE, unless work is performed in a laser area with limited access and appropriate safeguards, supervision, and control.
3. Fail-Safe Design: The protective enclosure and the laser system must be designed and fabricated so that if a failure occurs, the system will continue to meet the requirements for an enclosed laser operation.
4. Modifications to commercial laser systems must be evaluated. Contact the LSO for an evaluation. If the modifications decrease the safety controls, an SOP will be required.
5. Attenuated Viewing Windows: Use viewing windows containing a suitable filter material that will attenuate the transmitted laser radiation to levels below the MPE under all conditions of operation.
6. Warning Signs and Labels
   a. Label the enclosure with "CAUTION-ENCLOSED LASER" signs.
   b. Attach a label directly to the laser which gives the laser classification in the absence of the enclosure. Make sure that the label can immediately be seen when the enclosure is opened.

18.11 Controlling Associated Hazards

Many chemical and physical hazards other than laser radiation can be found in the laser area that must also be adequately controlled.

1. Electrical Equipment and Systems
   a. Always be aware of the high risk of injury and fire in laser operations because of the presence of electrical power sources.
   b. The installation, operation, and maintenance of electrical equipment and systems must conform to existing standards. Contact EHS for assistance.
2. Lighting
   a. Adequate lighting is necessary in controlled areas.
   b. If lights are extinguished during laser operation, provide control switches in convenient locations or install a radio controlled switch.
   c. Luminescent strips should be used to identify table and equipment corners, switch locations, aisles, etc.
   d. When ambient light is not sufficient for safe egress from a laser area during an electrical power failure, install emergency lighting.
3. Ionizing and Non-ionizing Radiation
   a. A laser operation may involve ionizing radiation that originates from the use of electrical power in excess of 15kV. If X-rays are generated a CAUTION-X-RAYS" sign must be prominently displayed.
   b. Microwave and radio frequency (RF) fields may be generated by laser systems or support equipment.
   c. Contact the Radiation Safety Officer to obtain an evaluation of these hazards before starting an operation.

4. Hazardous Materials
    a. Bring into the laser area only those hazardous materials that are needed for the operation.
    b. All hazardous materials must be properly used, stored and controlled. Consult Material Safety Data Sheets, other EHS safety plans and EHS for information.
    c. Do not allow laser beams and strong reflections to impinge on combustible materials, explosives, highly flammable liquids or gases or substances that decompose into highly toxic products under elevated temperatures, without providing adequate controls.
    d. Conduct or sponsor tests that establish the effects of beam interactions with hazardous materials. Test results can be used to determine safe parameters for laser operation.
5. Dyes and Solutions
    a. Dye lasers normally use a lasing medium composed of a complex fluorescent organic dye dissolved in an organic solvent. These dyes vary greatly in toxicity, mutagenicity, and potential carcinogenicity.
    b. All dyes must be treated as hazardous chemicals. Most solvents suitable for dye solutions are flammable and toxic by inhalation and/or skin absorption.
    c. Obtain Material Safety Data Sheets from EHS Office for all dyes and solvents.
    d. Use and store all dyes and solvents in accordance with the Materials Safety Data Sheets.
    e. Prepare and handle dye-solutions inside a chemical fume hood.
    f. Wear a lab coat, eye protection and gloves. Call EHS Office for assistance in glove selection.
    g. Pressure-test all dye laser components before using dye solutions. Pay particular attention to tubing connections.
    h. Install spill pans under pumps and reservoirs.
    i. Be alert to contaminated parts.
    j. Keep dye-mixing areas clean.
6. Water
    a. In general, lasers are water-cooled, so flooding is a possibility.
    b. Check hose connections regularly.

APPENDIX A APPLICATION FOR POSSESSION & USE

RSO-1
Page 1

NOVA SOUTHEASTERN UNIVERSITY

APPLICATION FOR POSSESSION AND USE OF RADIOACTIVE MATERIAL OR EQUIPMENT

PLEASE PRINT AND FILL OUT COMPLETELY.
PLEASE KEEP A COPY FOR YOUR RECORDS.

NAME (last, first)	POSITION / TITLE	DATE
DAPARTMENT: MAIL ADDRESS	PHONE:	E-MAIL

BUILDING & ROOM(S) WHERE RADIOACTIVE WORK WILL BE PERFORMED	PREVIOUSLY AUTHORIZED BY RADIATION SAFETY COMMITTEE AS: ☐ Qualified User For _____ Years ☐ General User

DO YOU PLAN TO USE RADIOACTIVE MATERIAL IN ANIMALS? ☐ YES ☐ NO
Will work involve use of > 100 mCi of a radionuclide with half-life greater than 120 days? ☐ YES ☐ NO
Will you be working with any biological hazards? ☐ YES ☐ NO

INSTRUMENTATION TO BE USED FOR RADIATION MONITORING

Type, Model, and Description of Instrument (include probe type) Serial No.

A._____
_

B._____
_

LABORATORY MONITORING/SURVEYS

☐ Any laboratory under my authorization will be surveyed at least once each calendar week if radioactive material is being used.

PERSONNEL MONITORING AND PROTECTION
Please refer to the **Radiation Dosimetry Guidelines** at the end of this application to determine the requirements for dosimetry.

- ☐ I currently have a whole body badge.
- ☐ I currently have a ring badge.
- ☐ I do not require a badge since I will be using only ^{14}C, ^{3}H, ^{35}S, or ^{33}P.
- ☐ I do not require a badge since I will be using less than quantities shown in RSP Dosimetry Guidelines
- ☐ I will call EHS to order a dosimeter.

SECURITY PLAN

Each Principal Investigator must submit a security plan for all areas under his/her supervision where radioactive materials or equipment are used and stored. Please submit this plan with this application.

DESCRIPTION OF LABORATORY / RADIOLOGY FACILITIES

Please attach a **map** of each room which includes the locations of fume hoods, work areas, waste areas, waste containers, shielding, radioactive material storage areas, radiological equipment and entrances and exits.

RSO-1
Page 2

NOVA SOUTHEASTERN UNIVERSITY

APPLICATION FOR POSSESSION AND USE OF RADIOACTIVE MATERIAL OR EQUIPMENT

PROPOSED USE OF EACH RADIONUCLIDE / EQUIPMENT (Include activity and brief description of procedure.)

NUCLIDE/ MACHINE	REQUESTED LIMIT	PROCEDURE	MAX. ACTIVITY PER PROCEDURE (mCi)	ESTIMATED # PROCEDURES PER MONTH / HOURS PER WEEK

RSO-1
Page 3

TRAINING

SUBJECTS	INSTITUTION(s)	DATES	NO. OF HOURS
PRINCIPLES AND PRACTICES OF RADIATION PROTECTION			
RADIACTIVITY MEASUREMENTS INSTRUMENTATION, AND DETECTION			
BASIC MATHEMATICS PERTAINING TO USE AND MEASUREMENT OF RADIOACTIVITY			
BIOLOGICAL EFFECTS OF RADIATION			

EXPERIENCE

NUCLIDES USED	QUANTITY, mCi	INSTITUTION	DATES	TYPE OF USE

SIGNATURE

NOVA SOUTHEASTERN UNIVERSITY RADIATION SAFETY PLAN CONTAINS THE POLICIES AND RULES WHICH GOVERN THE USE OF RADIATION PRODUCING MATERIALS AND EQUIPMENT AT NSU AS SPECIFIED BY THE RADIATION SAFETY COMMITTEE AND MUST BE ADHERED TO BY ALL USERS.

I HAVE READ AND WILL ABIDE BY THE UNIVERSITY'S PROGRAM REQUIREMENTS AND POLCIES SET FORTH IN THE RADIATION SAFETY MANUAL.

APPLICANT'S NAME: _____

DATE: _____

By my signature, I attest that all information provided on this application is true and accurate:

Applicant signature: _____ Date: _____

RADIATION DOSIMETRY GUIDELINES

You may be required to wear dosimetry during your radioactive material work. Personnel who are using radioactive materials in the amounts shown in the table will be issued dosimetry.

Radioisotope(s)	Activity, mCi	Type of Monitoring
^{14}C, ^{3}H, ^{33}P & ^{35}S	any amount	none required
^{32}P	< 6 mCi	none required
	≥ 6 mCi to < 30 mCi	ring dosimeter
	≥ 30 mCi	ring badge & whole-body dosimeter
^{45}Ca	< 50 mCi	none required
	≥ 50 mCi	ring dosimeter
Low Energy Gamma Ray Emitters, < 200 keV (^{125}I, ^{99m}Tc, ^{201}Tl)	< 50 mCi	none required
	≥ 50 mCi	ring and whole-body dosimeter
High Energy Gamma Ray Emitters, ≥ 200 keV (^{51}Cr, ^{131}I, ^{60}Co, ^{137}Cs)	< 2 mCi	none required
	≥ 2 mCi to < 5 mCi	ring dosimeter
	≥ 5 mCi	ring badge & whole-body dosimeter

APPENDIX B NOTICE TO EMPLOYEES

FLORIDA DEPARTMENT OF HEALTH

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION;
NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS

POSTING REQUIREMENT

THIS NOTICE MUST BE POSTED IN PLACES THAT PERMIT EMPLOYEES IN A RESTRICTED AREA TO SEE A COPY ON THE WAY TO OR FROM THEIR PLACE OF EMPLOYMENT.

The Department of Health has established standards for protection against radiation hazards in Chapter 64E-5, Florida Administrative Code.

YOUR EMPLOYER IS REQUIRED TO:

- Post or provide you a copy of the Department of Health rules and operating procedures that apply to your work and explain them to you.
- Apply the rules to work involving radiation sources.
- Post or provide you any Notice of Violation involving radiological working conditions, proposed civil penalties, and orders.

YOU ARE REQUIRED TO:

- Become familiar with the rules and the operating procedures that apply to your work.
- Observe the requirements to protect yourself and your co-workers.

WHAT IS IN THESE RULES:

- Limits on exposure to radiation and radioactive material in restricted and unrestricted areas
- Actions to take after accidental exposure
- Personnel monitoring, surveys, and equipment
- Caution signs, labels, and safety interlocks
- Exposure records and reports
- Options for workers about Department of Health inspections
- Related matters

REPORTS ON RADIATION EXPOSURE

Your employer must give you a written report if you receive an exposure above the limits in the rules or in the license. The maximum limits for exposure to employees are in Part III of the rules. However, your employer should keep your radiation exposure as low as reasonably achievable.

If you work where personnel monitoring is required:

- Your employer must give you a written annual report of your radiation exposures.
- Your employer must give you a written report of your radiation exposures when you terminate employment.

INSPECTIONS

Representatives of the Department of Health inspect all licensed and registered activities. Any worker or worker representative who believes that there is a violation of Chapter 404, Florida Statutes; Chapter 64E-5, Florida Administrative Code; or the terms of the employer's license or registration can request an inspection by contacting the Bureau of Radiation Control, Bin C21, 4052 Bald Cypress Way, Tallahassee, FL 32399-1741 (850) 245-4266. The request must state specific reasons for the inspection. During inspections, Department of Health inspectors can confer privately with workers and any worker can bring to the attention of the inspectors any past or present condition that they believe contributed to or caused any violation.

Copies of Chapter 64E-5, F.A.C., the license or registration, operating procedures, any notice of violation about working conditions, penalty orders issued, and responses can be examined at:

Notice to Employees - 3/01

APPENDIX C PERMIT AMENDMENT FORM

RSO -2

NOVA SOUTHEASTERN UNIVERSITY PERMIT AMENDMENT FORM

This form must be submitted to the Radiation Safety Officer (RSO) if you would like to add an isotope, increase a possession limit, or add a protocol to an existing radioactive materials use permit. Send the completed form to the RSO at rso@nova.edu or through campus mail.

Authorized User: Department:

Phone: Location: Mail Code:

Contact Person: Location Phone: Lab Phone:

List all locations where radioisotope(s) will be used or stored:

RADIOISOTOPES	MAXIMUM POSSESSION LIMIT*

* Maximum Possession Limit is the maximum quantity of the radioisotope you may have on hand at any time; it is the sum quantity of the radioisotope in storage, in use and in waste.

		Waste distribution (as percentages)						
No.	Protocol title	Solid	Liquid aqueous	Liquid flammable	Scintillation vials aqueous	solvent	Animal	Stock Vial
1								
2								
3								

On a separate sheet of paper, describe the handling, use and disposal of the radioisotopes for each protocol listed in. Include in this description the radiolabeled compounds used, any chemicals added or dilutions performed, and the volumes and types of radioactive wastes generated. If any special hazards (e.g., toxicity, carcinogenicity, volatility, etc.) apply to the protocol, please discuss the inactivation or neutralization of the applicable hazards and/or discuss the management and control of potentially contaminated animal by-products (excretions, bedding, etc.) or field use by-products (air release, run-off, etc.). Also describe the precautions, safe handling procedures and equipment that will be used to reduce exposure to the ionizing radiation.

These descriptions must be type written.

"To the best of my knowledge, this application is complete and accurate. All individuals who will work under this permit have been properly trained in the use and handling of radioactive materials."

Authorized User's signature: _____ Date: _____

APPENDIX D Radiotoxicity Groups

Radiotoxicity Groups

	Activity Limits		
	Low	Medium	High
Low Hazard ^{3}H, ^{7}Be, ^{14}C, ^{19}F, ^{59}Ni, ^{69}Zn, ^{71}Ge, ^{238}U, Natural Thorium, Natural Uranium, Noble gases	Up to 5 mCi	5 mCi to 5 Ci	Above 5 Ci
Medium Hazard ^{24}Na, ^{31}Si, ^{32}P, ^{33}P, ^{35}S, ^{36}Cl, ^{42}K, ^{47}Sc, ^{49}V, ^{51}Cr, ^{54}Mn, ^{56}Mn, ^{55}Fe, ^{59}Fe, ^{64}Cu, ^{65}Zn, ^{72}Ga, ^{76}As, ^{86}Rb, ^{89}Ar, ^{90}Y, ^{91}Y, ^{95}Zr, ^{95}Nb, ^{99}Mo, ^{103}Ru, ^{103}Pd, ^{105}Rh, ^{105}Ag, ^{109}Cd, ^{111}Ag, ^{113}Sn, ^{127}Te, ^{129m}Te, ^{140}Ba, ^{140}La, ^{143}Pr, ^{147}Pm, ^{151}Sm, ^{166}Ho, ^{170}Tm, ^{177}Lu, ^{183}Re, ^{190}Ir, ^{192}Ir, ^{191}Pt, ^{193}Pt, ^{196}Au, ^{198}Au, ^{199}Au, ^{200}Tl, ^{201}Tl, ^{202}Tl, ^{204}Tl, ^{203}Pb, ^{220}Rn, ^{222}Rn, ^{235}U	Up to 2 mCi	2 mCi to 100 mCi	Above 100 mCi
High Hazard ^{22}Na, ^{45}Ca, ^{46}Sc, ^{60}Co, ^{106}Ru, ^{125}I, ^{129}I, ^{131}I, ^{137}Cs, ^{144}Ce, ^{154}Eu, ^{182}Ta, ^{210}Bi, ^{211}At, ^{224}Ra, ^{233}U	Up to 1 mCi	1 mCi to 20 mCi	Above 20 mCi
Very High Hazard ^{210}Pb, ^{210}Po, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{228}Th, ^{230}Th, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{242}Cm	Up to 0.5 mCi	0.5 mCi to 5 mCi	Above 5 mCi

APPENDIX E Annual Limits

Annual Limits on Intake (ALI) and Derived Air Concentrations (DAC) for Occupational Exposure.
Concentration levels for Sewer Release for Non Gaseous Compounds of Selected Radionuclides

Nuclide	**Oral Ingestion**	**Inhalation**	**Sewer Release**	
	ALI µCi	ALI µCi	DAC µCi/ml	Average Monthly Concentration µCi/ml
^{3}H	8×10^{4}	8×10^{4}	2×10^{-5}	1×10^{-2}
^{14}C	2×10^{3}	2×10^{3}	1×10^{-6}	3×10^{-4}
^{32}P	6×10^{2}	9×10^{2}	4×10^{-7}	9×10^{-5}
^{35}S	1×10^{4}	2×10^{4}	7×10^{-6}	1×10^{-3}
^{45}Ca	2×10^{3}	8×10^{2}	4×10^{-7}	2×10^{-4}
^{65}Zn	4×10^{2}	3×10^{2}	1×10^{-7}	5×10^{-5}
^{125}I	40 1×10^{2}(thyroid)	60 2×10^{2}(thyroid)	3×10^{-8}	2×10^{-5}
^{131}I	30 90 (thyroid)	50 2×10^{2}(thyroid)	2×10^{-8}	1×10^{-5}

The above values are limits which would result in exposure to an annual committed effective dose equivalent of 5 rem to an adult individual or an annual committed dose equivalent of 50 rems to an individual organ or tissue.

APPENDIX F Radioactive Material Transfer Form

RSO-3

NOVA SOUTHEASTERN UNIVERSITY **RADIOACTIVE MATERIAL TRANSFER FORM**

1. The Radiation Safety Officer (RSO) must approve all radioactive transfers.
2. Complete all sections of this transfer form. Requests will be delayed if the form is not complete.
3. Transfer request forms must be received by Environmental Health and Safety Office and approved by RSO prior to isotope transfer.
4. Mail or fax the completed form to ___-___-____, Call ___-___-____ if you have questions

Fax: ( ) ___-____

Authorized User (first and last name)	Department	
Person to Contact if Questions or Problems	Contact Person Phone	Delivery Address (room and building)

Authorized User to receive the isotope	Department Name	Phone Number

Request to transfer				Only **one** item per row may be listed on this form.	
1	Radio-Labeled Compound	Isotope	Quantity	Unit Activity (mCi)	Requested Delivery Date
2					
3					
4					
5					

How much delay is acceptable for isotope transfer? ____ Days.

Date of Request: _____ Requesting Person's Signature: _____

Notes:

APPENDIX G Radioactive Material Request Form

RSO-4

NOVA SOUTHEASTERN UNIVERSITY **RADIOACTIVE MATERIAL REQUEST FORM**

Return this form to the RSO or FAX to ___-____ by 3:00 pm for same day ordering.

Date: _____

Name: _____Authorized User: _____

Building: _____ Room #: _____

Vendor: _____ Date item(s) needed by: _____

Contact Phone #: _____ Fax #: _____

P.O. number: _____

Purchase Card: _____ Approved by: _____

Qty.	Radionuclide	Chemical compound	Supplier	Catalog #

Receipt (RSO use only)

Date of receipt: _____ User: _____

Package condition: Okay _____ Damaged/ Wet _____

Nuclide: _____ Chemical form: _____ Activity:_____mCi

Transport Label: None ☐ White ☐ Yellow-II ☐

External Rad. Surface level: _____mR/hr Calib. Date: _____

Background_____mR/hr

Background wipe: _____ Package Wipe: _____

Lab Receipt Signature_____

APPENDIX H Statement of Training and Experience

RSO-5

NOVA SOUTHEASTERN UNIVERSITY **STATEMENT OF TRAINING AND EXPERIENCE**

Documentation for non-RAM Users

Print Name: _____ Authorized User: _____

Radioactive Material: _____ Department: _____

University Phone: _____ University Email Address: _____

Check One: ☐ FACULTY ☐ STAFF ☐ STUDENT

I plan to use (check all that apply):
☐ unsealed sources of radionuclides (which ones? _____)
☐ X-ray generator ☐ sealed sources only

A. Have you ever received **formal training** in the following topics? Check YES or NO below. [Radiation Safety Courses at other institutions and lectures on the topics as part of college level coursework (for example- Physics, Biology, Chemistry, etc.) would be considered formal training.]

Principles and Practices of Radiation Protection	☐ YES	☐ NO
Basic nuclear interactions	☐ YES	☐ NO
Biological effects of radiation	☐ YES	☐ NO
Exposure control basic principles	☐ YES	☐ NO
Calculations basic to the use and measurement of radioactivity	☐ YES	☐ NO
Radioactivity monitoring techniques and instruments	☐ YES	☐ NO

If you checked YES for any of the above, complete the section below.

Name of the course/lecture	Location where training was received

B. If you ever handled radioactive materials before and thereby received **on the job training** in the above topics, complete the table below--

Radiouclide Used	Maximum experimental activity used	Location where radionuclide was used	Length of time radionuclide was used (# of years)	Experimental procedure(s) performed with radionuclide

NOVA SOUTHEASTERN UNIVERSITY **STATEMENT OF TRAINING AND EXPERIENCE**

C. Have radiation exposure records been maintained for you at another institution?
Check One: ☐ YES ☐ NO
If YES, indicate name of institution(s) _____

I have read and will abide by the University regulations set forth in the NSU Radiation Safety Plan.

Signature _____

Today's Date: _____

If additional space is required, use the back of this form or attach additional sheets.

APPENDIX I Declaration of Pregnancy

RSO-6

NOVA SOUTHEASTERN UNIVERSITY **DECLARATION OF PREGNANCY**

I _____ hereby am declaring I am pregnant.
PRINT NAME

I believe I became pregnant in _____
MONTH YEAR

I understand that my occupational radiation dose during my entire pregnancy will not be allowed to exceed 0.5 rem (500 mrem), unless that dose has already been exceeded between the time of conception and submitting this letter. I also understand that meeting the lower dose limit may require a change in job or job responsibilities during my pregnancy.

If I find out that I am not pregnant, or if my pregnancy is terminated, I will promptly inform you that my pregnancy has ended.

Signature: _____ Date: _____

RSO Review: _____ Date: _____

APPENDIX J Quarterly Survey Report

RSO-7

NOVA SOUTHEASTERN UNIVERSITY **QUARTERLY SURVEY REPORT**

Authorized User: _____ Quarter reported: 1st 2nd 3rd 4th

Department: _____ Year: _____

☐ **I did not have possession of any radioactive materials during this quarter.**

A copy of this form must be completed and sent to the Radiation Safety Committee (RSC) at the end of each calendar quarter. Keep the original on file for review by the Department of Health and/or Bureau of Radiation Control. Failure to submit a quarterly report by the appropriate due date will result in the suspension of your privileges to order and/or receive radioactive materials.

Due Dates: Your report should reach the RSO by the dates indicated following each calendar quarter.

First Quarter	(Jan, Feb, Mar)	due by: **April 1st**
Second Quarter	(Apr, May, Jun)	due by: **July 1st**
Third Quarter	(Jul, Aug, Sep)	due by: **October 1st**
Fourth Quarter	(Oct, Nov, Dec)	due by: **January 1st**

Inventory Date determined: _____	Radioisotope	Inventory Activities (mCi) Stock	Waste	Total
Report the inventory for each radioisotope listed on your permit (even if it is zero). The activity you report for stock material and waste must be decay corrected to the date you have indicated above.	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
Refer to instructions listed below on decay correction of radioactive waste.	_____	_____	_____	_____
	_____	_____	_____	_____

Personnel

List and denote the names of those staff members who are new (A: add), have changed their name (C: change), or who no longer work under your permit (D: delete) since the last quarter. Attach additional pages if needed.

_____ _____ _____

_____ _____ _____

_____ _____ _____

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Page 2

NOVA SOUTHEASTERN UNIVERSITY **QUARTERLY SURVEY REPORT**

Radioisotope Use Areas	Building	Room	Status (circle one)
List all areas were radioisotopes are handled or stored, and indicate the status of each area according to the following designations:	_____	_____	A or S
	_____	_____	A or S
(A) Active: Handling and use of radioactive materials during quarter.	_____	_____	A or S
(S) Storage: Storage only, no removal or use during quarter	_____	_____	A or S
	_____	_____	A or S

Report completed by:_____ Date:_____Phone:_____

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Page 3

NOVA SOUTHEASTERN UNIVERSITY **QUARTERLY SURVEY REPORT**

Authorized User:	Dept.:	
Surveyed by:	Phone:	Date:
Building:	Room Number(s):	

Insert map of room(s) and indicate doorway number(s)

Smear Survey Data			Survey Meter Data		
Radioisotopes Analyzed:			Instrument Used/SN:		
Counting Efficiencies (%):			Background CPM or mR/hr:		
Instrument Used:			No.	Location	CPM or mR/hr
No.	Location	DPM/100 cm^2			

If contamination is detected, decontaminate to < 100 DPM/100 cm^2 (smearable) or <3x Background (fixed) and document results on this form.

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Page 4

NOVA SOUTHEASTERN UNIVERSITY **QUARTERLY SURVEY REPORT**

List results of post-decontamination surveys below if needed.					
No.	Swipe Location	DPM/100 cm^2	No.	Survey Meter Location	DPM/Probe
Comments:					

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Page 5

NOVA SOUTHEASTERN UNIVERSITY **QUARTERLY SURVEY REPORT**

INSTRUCTIONS:

Inventory

An inventory of all radioactive materials under the Authorized User permit must be submitted to the RSO at the end of each calendar quarter. This inventory must include the total, decay corrected activity of each radioisotope in stock form as of the end of the quarter, plus the total, decay corrected activity of each radioisotope in waste form as of the end of the quarter. The procedure to follow for determining these inventories is listed below.

NOTE: Decay correction will not be necessary for the following:

1) Radioisotope with half-life > 2 years, if stock vial has been in possession for < 90 days.
2) Radioisotope with half-life > 4 years, if stock vial has been in possession for <180 days.
3) Radioisotope with half-life > 8 years, if stock vial has been in possession for < 1 year.
4) Radioisotope with half-life > 100 years, no decay correction will be required.

1. Stock Vial Inventory

Use Appendix D (Monthly Inventory Record Form) for quantities of radioisotopes currently on hand in stock form.
Use the following procedure to determine total stock activity for a radioisotope:

- Take the activity remaining in the stock vial as of the last entry on Appendix D (disregard entries that indicate zero remaining activity).
- Determine the number of days from date of receipt of the stock vial to the end of the calendar quarter (note: if your activity remaining in the stock vial has already been decay corrected to the last date of stock withdrawal, determine the number of days between *this* date and the end of the quarter to determine the fractional decay below).
- Determine the fractional decay for this number of days. Use the following link for decal calculations: http://www.ehs.washington.edu/rso/calculator/activity_calc.shtm
- Multiply this fractional decay times the activity remaining in the stock vial to get the activity in the stock vial as of end of quarter.
- Repeat this process for each stock vial of this radioisotope that has residual activity, and add these decay corrected activities to obtain the activity of this radioisotope remaining as of the end of the quarter.
- Record the decay corrected total for this radioisotope on the quarterly report form under the section for stock vial inventory.
- Repeat the above process for each radioisotope in your inventory.
- If you are approved for a radioisotope, but have no stock vial or waste inventory on hand as of the end of the quarter, be sure to enter a "0" for this radioisotope inventory on the quarterly report form.

2. Radioactive Waste Inventory

- Determine the activity in the waste containers and carcasses as of the end of the quarter.
- Determine the fractional decay for this number of days.
- Total the decay corrected activities for each radioisotope from all waste containers and carcasses, enter under waste inventory on the quarterly report form.

3. Total Inventory

Add the stock vial inventory and the waste inventory for each radioisotope and record under the "Total" heading of the Quarterly Report Form.

Personnel
Record the names of all personnel who are new, have changed their names, or who no longer work under the radioactive materials permit since the last Quarterly Report was submitted. Denote the new names with an '**A**', the changes with a '**C**', and the deletions with a '**D**'.

With an addition, also include the radioisotopes and stock vial quantities (in mCi) that the individual would most likely handle. This will aid in the appropriate assignment of dosimeters if required.

With a deletion, please contact the individual responsible for the distribution and collection of dosimeters within your group and confirm that all dosimeters have been returned to the RSO if the "deleted" person has left the University. If a person is to be "deleted" from your group, but will remain at the University and will continue to use the dosimeters, please provide a forwarding University address and phone number so the appropriate changes can be made to their dosimetry records.

Radioisotope Laboratory and Use Area - List all radioisotope use and storage areas which were posted as restricted "Radioactive Materials" areas at any time during the quarter. This includes all laboratories, cold rooms, counting rooms, waste rooms, storage rooms and animal rooms where storage or use of radioactive materials was authorized under your permit by the RSO.

Only areas where **no handling** of any radioactive material occurred during the entire calendar quarter may be classified as "Storage" areas. All other areas where radioactive materials are handled must be designated as "Active" use areas.

NOVA SOUTHEASTERN UNIVERSITY **QUARTERLY SURVEY REPORT**

RADIOISOTOPE LABORATORY AND USE AREA SURVEYS

Contamination survey results, and in some cases exposure rate survey results, must be submitted with the Quarterly Report. All restricted radioisotope areas for which the authorized user is responsible must be accounted for on the Quarterly Report. A diagram of your areas, showing where smears were taken, must also be included with the survey results. Identify the area by using both the building name and room number(s).

1. Frequency of Surveys

- All active, restricted radioisotope areas that are classified as "Low Risk" must have contamination surveys completed each month, and the results submitted with the Quarterly Report. Refer to your copy of the radioisotope use permit for the risk classification of your areas.
- All restricted areas where there was **no handling** of radioactive materials during the entire calendar quarter must have one survey completed **during** that quarter. This survey should be taken in the vicinity of any stored radioisotopes (e.g., refrigerator, freezer, cold room shelf, etc.), or radioactive waste containers.

2. Survey Information Requirements

Surface contamination smear surveys are required for all restricted radioisotope areas. The surveys should be conducted using dry filter paper and analyzed with the appropriate counting instrument (liquid scintillation or auto-gamma counter). All results must be reported in disintegrations per minute (DPM).

- Record on the survey form which radioisotopes were used in the area.
- Record what counting efficiency was used in determining DPM.
- Record the make and model of the counting instrument.
- Number the smears and indicate on the survey map where these smears were taken.
- Describe their locations in the **SMEAR SURVEY DATA** column. Locations should include those where radioactive materials are stored, handled, and/or discarded.

Examples:

* work station bench top (or fume hood working surface)
* floor in front of work station
* refrigerator/freezer shelves and handles
* floor in front of refrigerator/freezer
* equipment surfaces, knobs, and handles (centrifuge, incubator, waterbath, etc.)
* radioactive waste container lids and handles
* floor area around radioactive waste containers
* sink basins and faucet controls where lab ware is rinsed
* liquid scintillation counter and auto-gamma counter surfaces, knobs and buttons
* door handles and floors of access points to all restricted areas

- Record the DPM per 100 square centimeters for each smear.
- DPM = (smear CPM - background CPM) ÷ (fractional counting efficiency)

If the result of a smear is > 100 DPM/100 cm^2, you must decontaminate the area to a level less than 100 DPM, resurvey and submit the new results with the Quarterly Report.

If high energy beta emitters or gamma emitters are used in a radioisotope area, an exposure rate survey is also required. A portable Geiger-Mueller (GM) survey meter is often used to meet this requirement. Complete the right-hand column of the survey form.

- Record the make and model of the instrument.
- Record the background counts per minute (CPM) or exposure rate (mR/hr).
- Record the CPM or mR/hr for the locations you have indicated on the survey map. Locations should include those where radioactive materials are stored, routinely handled and discarded. Measurements should be taken at normal working or occupancy positions.

  Examples:

  * Work station, chest level at normal standing distance
  * Refrigerator/freezer (or other storage area) at normal working distance
  * Radioactive waste containers at normal working distance

If an exposure rate reading exceeds 2.5 mR/hr at a normal working distance, you must take immediate action to reduce the exposure (e.g., modify shielding). The RSC recommends that exposure rates remain below 0.25 mR/hr at normal working distances.

3. Determination of DPM/100 cm^2

As stated in the previous sections, the results of all radioisotope smear surveys must be reported in disintegrations per minute for an area of 100 square centimeters (DPM/100 cm^2). One hundred square centimeters is approximately equal to the area covered by a Whatman 1™ filter paper which smears approximately 20 inches of a surface. Initial smear surveys may cover areas greater than this, but if contamination is found an area must be decontaminated to a level below the 100 DPM/100 cm^2 limit.

Use one of the following options to determine DPM for your smear survey results.

Beta Emitters

- Default Option. The default method for converting counts per minute (CPM) to DPM is to use the open window (0-2 MeV) setting on the liquid scintillation counter and to use the conservative counting efficiency of 25%.
  Therefore:

  DPM = (Gross smear CPM - Background CPM) ÷ (0.25)

- Three Window Option. If radioisotopes with differing beta energies are used and analyzed (e.g., H-3, C-14, S-35, P-32, P-33) and the liquid scintillation counter can be programmed to establish three distinct counting windows, the conservative counting efficiencies to use are:

  25% for Window 1 (0.0 - 0.016 MeV)
  50% for Window 2 (0.016 - 0.17 MeV)
  80% for Window 3 (0.17 - 2.0 MeV)

  Therefore:

  (Gross Window 1 CPM - Background Window 1 CPM) ÷ (0.25) = DPM 1
  (Gross Window 2 CPM - Background Window 2 CPM) ÷ (0.50) = DPM 2

  +(Gross Window 3 CPM - Background Window 3 CPM) ÷ (0.80) = DPM 3
  Total DPM = (Sum of three windows' DPM)

Gamma emitters and Beta/Gamma Emitters

- Auto-gamma counters. For radioisotopes that are gamma emitters or beta/gamma emitters, the default fractional counting efficiencies to use for auto-gamma analysis are:

Radioisotope	Efficiency*
Cr-51	0.04
I-131	0.40
Tc-99m	0.50
I-125	0.60
In-111	0.80

* Efficiency values assume the use of a 2" well-type NaI(TL) crystal with an energy window adjusted for the gamma photon peak of the radioisotope listed.

Therefore:

DPM = (Gross smear CPM - Background CPM) ÷ (Efficiency)

APPENDIX K Area Survey Report

RSO-8

NOVA SOUTHEASTERN UNIVERSITY **AREA SURVEY REPORT**

Authorized User:	Dept.:	
Surveyed by:	Phone:	Date:
Building:	Room Number(s):	

Room Diagram

Wipe #	Wipe Result in DPM	Meter Survey results (CPM or mR/hr)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

Attach printout of wipe result data

Survey Meter Model:	Calibration Date:
Meter Serial #:	Background (CPM or mR/hr):
Surveyed by:	Date of Survey:

DPM = (smear CPM - background CPM) ÷ (fractional counting efficiency)

Authorized User's Signature: _____

Date: _____

APPENDIX L RADIOACTIVE MATERIALS MONTHLY INVENTORY RECORD FORM

RSO - 9

Nova Southeastern University

RADIOACTIVE MATERIALS MONTHLY INVENTORY RECORD FORM

Authorized User:_____________________________ Location:____________________________ P.O.#:_________________ Vendor: _____________

Radionuclide:____________ Inventory Control #:_____________ Chemical Form:______________ Source/Lot #: _______________

Date Received: ______________________ Quantity(mCi):______________ Volume: ________________

Specific Activity:__________________ Date Delivered:__________________ Account #: ________________

USE RECORD			TRANSFER AND DISPOSAL RECORD – List all quantities in millicuries (mCi)							
Transfers from shipping vial/stock solutions			Date	Sewer	Other – Decay, Transfer to another A.U. (Specify)	Quantity transferred to waste containers for pick-up by RSO				
Date	Removed (mCi)	Remaining (mCi)				Liquid Waste	Animal Carcasses	Dry/Solid Waste	Liquid Scintillation Vials	Notes/ Remarks

APPENDIX M CHARACTERISTICS OF COMMONLY USED RADIONUCLIDES

Radionuclide	Radiation(s) emitted and energy	Radiological Half-Life	Biological Half-life	Effective Half-life	Critcal Organ	Maximum Permissible Body Burden	Shielding Required	Special Considerations
H-3	Beta particle: Emax – 18.6 keV Emean – 5.7 keV	12.3 years	12 days	12 days	whole body	1 mCi whole body	None	None
C-14	Beta particle Emax – 156 keV Emean – 49 keV	5730 years	10 days	10 days	whole body fat	.4 mCi whole body .3 mCi fat	None	Do not generate carbon dioxide which can be inhaled.
P-32	Beta particle: Emax – 1709 keV Emean – 690 keV	14.3 days	1155 days	14.1 days	Bone	.006 mCi bone .030 mCi whole body	1 cm Plexiglass	P-32 is highest energy radionuclide used in research labs. Avoid bremstrahlung x-ray production by shielding with plexiglass and **not Lead.**
P-33	Beta particle: Emax – 246 keV	24.4 days	1155 days	23.9 days	Bone	.032 mCi whole body	1 cm Plexiglass	None
S-35	Beta particle: Emax – 167 keV Emean – 49 keV	87.4 days	623 days	76 days	whole body testes	.4 mCi whole body .090 mCi testes	None	Open vials in ventilated enclosures to prevent inhalation
Ca-45	Beta particle: Emax – 257 keV Emean – 86 keV	165 days	49.3 days	162 days	Bone	.030 mCi whole body	1 cm Plexiglass .01 inch Al foil	None
Cr-51	Gamma photon: 320 keV X-ray: 5 keV	28 days	616 days	27 days	lower large intestines	.800 mCi whole body	3.2 mm Lead	None
Co-57	Gamma photons: 122 keV (85.5%) 136 keV (10.8%) 14 keV (9.5%) 692 keV (.16%)	270.9 days	276 days	9.2 days	lower large intestines	.200mCi whole body	3.2 mm Lead	None
I-125	Gamma photon: 35 keV (7%) X-ray: 27-32 keV	60 days	138 days	41.8 days	Thyroid	.00115 mCi thyroid .006 mCi whole body	.25 mm Lead	May be volatile when opening vial; therefore open vials in ventilated enclosures such as certified hoods. Do not make I-125 solutions acidic or do not store frozen; both lead to formation of volatile elemental iodine
I-131	Beta particle: Emax – 806 keV Emean – 180 keV Gamma photons: 364 keV (81.8%) 637 keV (7.2%) 284 keV (5.9%) 80 keV (2.4%) 723 keV (1.8%)	8.04 days	138 days	7.6 days	Thyroid	.00014 mCi thyroid .050 mCi whole body	12.7 mm Lead	Same as 1-125. Additional requirements for gamma radiation shielding

APPENDIX N Radiation Emergency Response Guidelines

TYPE OF EMERGENCY	HAZARD	IMMEDIATE PRECAUTIONS	FOLLOW-UP
Minor Spills (Usually micro-curie amounts)	*Radiation*: No immediate radiation hazard to personnel. *Contamination*: Low	• Notify all persons in room. • Confine spill immediately. • Notify Radiation Safety Officer (RSO).	Permit no one to work in area until approved by Radiation Safety Officer (RSO).
Major Spills (Usually milli-curie amounts)	*Radiation*: No immediate radiation hazard to personnel. *Contamination*: Low	• Notify others in room or area to vacate. • Confine spill immediately. • Make no attempt to clean up spill. • Switch OFF all fans and close all windows. • Vacate room or area. • Provide temporary barricade and warning signs. • Notify RSO.	Decontamination of personnel and equipment (including spill) to be carried out by or under supervision of RSO.
Accident Involving: - Dust - Mist - Fumes - Vapors - Gases	*Radiation*: No immediate radiation hazard to personnel. *Contamination*: Low	• Notify others in room or area to vacate. • Switch OFF all fans and close all windows. • Vacate room or area. • Provide temporary barricade and warning signs. • Notify RSO.	Do not re-enter until approved by RSO.
Minor Injuries Involving: - Radiation Hazard - Contamination	*Contamination*: Wounds usually greatest hazard.	• Wash wound immediately in running water. • Call physician of choice. • Notify RSO.	Permit no one involved in accident to return to work until approved by RSO and physician.
Major Injuries Involving: - Radiation Hazard - Contamination	*Contamination: Wounds usually greatest hazard.*	• Life threatening situations take precedence over contamination control.	Permit no one involved in accident to return to work until approved by RSO and physician.
Fires involving: - Radioactivity	*Radiation: No immediate radiation hazard to personnel.* *Contamination: Low*	• Notify others in room and building to vacate. • Attempt to extinguish fire if no radiation hazard & can be safely done. • Call Campus Police ASAP (911). • Notify RSO.	Emergency activities will be governed by or in cooperation with RSO. Campus Police will determine whether local Fire Department is to be called.

APPENDIX O Request for Radioactive Waste Pick-Up

RSO -10

Nova Southeastern University

Request for Radioactive Waste Pick-Up

I. REQUEST INFORMATION:

Pickup Requester: _____ Date: MM/DD/YY Ext: _____

Authorized User: _____ Waste Location: _____

II. INSTRUCTIONS:

1. Ensure each container has been properly labeled
2. Enter the following information for each container of waste:

Container #: Reference number that corresponds to the number used o radioactive waste label.

Radionuclide: Isotope present in waste. Note: For multiple isotopes/container, use separate entry for each isotope.

Activity: Current decayed activity (mCi) for the isotope at the time of the request for pickup.

Reference Date: Activity reference date from stock vial.

Form: Physical form of the waste. Enter one of the following:

- Dry - Aqueous liquid - Organic liquid - Scintillation vials - Other (describe)

Quantity: Quantity of waste in each container. Gallons or cubic feet (ft^3)

3. Email (RSO@nova.edu) or fax (954-262-3900) a copy for the form to EHS Office. EHS Office will contact to schedule a waste pick-up.

Container #	Isotope	Activity	Ref. Date	Form	Quantity	Notes

Authorized User Signature: _____ **Date: _____**

~ EHS USE ONLY ~

Pick-Up Date: _____ **Picked-up By: _____**

APPENDIX P Radiation Safety Quiz

NSU - Radiation Safety Quiz

Last Name: First Name: M.I.

Department: Phone: Mail Code:

I. True/False Questions:	**True**	**False**
1. Exposure to ionizing radiation can cause cancer.	☐	☐
2. Cells that normally proliferate more rapidly are most sensitive to ionizing radiation.	☐	☐
3. Because the alpha particles are slow moving, they are not an internal exposure hazard.	☐	☐
4. Low energy beta emitters (e.g. H-3) cannot be detected with survey instruments, therefore contamination of laboratory equipment can be neglected.	☐	☐
5. Cleaning up a radioactive material spill should be put off until the end of the day since you may spill more material, and it would be a waste of time to do it twice.	☐	☐
6. It is acceptable to keep your lunch in a refrigerator labeled "Caution - Radioactive Material", as long as your lunch is tightly sealed.	☐	☐
7. Radioactive material may be shipped from a vendor directly to the lab.	☐	☐
8. It is an acceptable practice to leave radioactive material unsecured if you know exactly where it is and will be back WITHIN five minutes.	☐	☐
9. NSU policy permits the disposal of liquid radioactive materials in sink drains.	☐	☐
1O. Annual radiation refresher training is a mandatory requirement.	☐	☐

II. Multiple Choice Questions:

11. Your liquid waste container label should have which of the following items of information:

- ☐ Date of disposal
- ☐ Isotope and activity
- ☐ Identification of other hazardous materials and chemicals
- ☐ All of the above

12. Before ordering radioactive materials you should:

- ☐ Contact the Environmental Health & Safety Office
- ☐ Ensure the quantities are within the limit of your license
- ☐ All required training has been performed
- ☐ All of the above

13. You accidentally spill a small amount of radioactive material on your skin. You should:

- ☐ Call the Environmental Health & Safety Office
- ☐ Go to the University Health Center
- ☐ Wash your skin gently with hand soap and water
- ☐ First (C), then (A)

14. In keeping with the NRC policy of maintaining radiation exposures "As Low As Reasonable Achievable" (ALARA), the NSU Radiation Safety Committee has established an administrative policy that occupational radiation exposures not exceed:

- ☐ 10% of the maximum legal exposure limit
- ☐ 25% of the maximum legal exposure limit
- ☐ 50% of the maximum legal exposure limit
- ☐ 100% of the maximum legal exposure limit

15. Present radiation safety standards for occupational exposure to whole body radiation limits an individual's dose equivalent to:

- ☐ 170 mrems/year
- ☐ 5000 mrems/year
- ☐ 100 mrem in one week
- ☐ 12.5 mrem in one hour
- ☐ 5 x (worker's age - 18 years) rems in one year

16. What is the average persons annual radiation dose in the United States due to non-occupational sources?

- ☐ 2500 mrem/year
- ☐ 2000 mrem/year
- ☐ 360 mrem/year
- ☐ 30 mrem/year

17. The most important factor for determining the exposure hazard of a particular isotope is:

- ☐ Activity
- ☐ Decay energy
- ☐ Half-value Layer
- ☐ Physical state

18. Which type of radioactive decay produces light, fast moving particles?

- ☐ Alpha
- ☐ Gamma
- ☐ Beta
- ☐ None of the above

19. You have received an isotope quantity identified as 10 mCi. The Curie (Ci) is one unit for measurement of:

- ☐ The ability of photons to produce ionizing radiation
- ☐ Rate of radioactive events (i.e. disintegrations per second)
- ☐ The amount of energy absorbed by tissue
- ☐ All of the above

20. You can reduce your exposure to radiation by doing the following:

- ☐ Increasing your distance from the source
- ☐ Decreasing the amount of time near the source
- ☐ Provide shielding between yourself and the source
- ☐ None of the above

21. At a MINIMUM, how often must wipe tests be performed when using Carbon 14 or Tritium (3H)?

- ☐ Every week
- ☐ Every day
- ☐ After each experiment
- ☐ A survey meter can be used instead of wipe tests with C-14 and H-3.

22. Survey meters can be used for (check as many as appropriate):

- ☐ Sulphur 35
- ☐ Carbon 14
- ☐ Tritium (3H)
- ☐ Phosphorus 32

23. You are using P-32 in the lab and are using an appropriate GM counter. You check the battery to verify that it is functioning. Which of the following techniques is correct for detection of contamination?

- ☐ Place the detector in contact with the surface to be monitored.
- ☐ Place the detector a few inches away from the surface and move it rapidly to assure a large area is scanned.
- ☐ First cover the detector with a plastic cover and do the same thing as in (b).
- ☐ Place the detector near the surface and move it slowly while observing the meter reading or listening to the audio output.

24. Which of the following statements is true?

- ☐ Dosimeters should be worn with the printed information facing away from the part of the body where the highest dose is expected.
- ☐ A NSU issued dosimeter can be worn at another facility with approval from the RSO.
- ☐ It is acceptable to occasionally expose your dosimeter to radiation in order to"test" it.
- ☐ All of the above are true

25. If you lose your film badge, you should:

- ☐ Notify the EHS office immediately to obtain a replacement.
- ☐ Borrow someone else's badge
- ☐ Do without one until next month's badge arrives
- ☐ Estimate your exposure with a survey meter.30 mrem/year

26. What is the principal reason for wearing a dosimeter (ring or badge)?

- ☐ It signifies that the worker is authorized to work with radiation.
- ☐ The results from a film badge, TLD badge, or TLD ring comprise a permanent record of an individual's occupational radiation exposure history.
- ☐ The use of the badge replaces the need for surveys in the lab.
- ☐ The dosimetry will absorb the radiation and reduce the individual's exposure.

27. Beta particles:

- ☐ Are limited from the nucleus with discrete energies.
- ☐ Are capable of creating bremsstrahlung radiation in materials.
- ☐ Are essentially identical to a proton.
- ☐ All of the above.

28. The abbreviation "mrem" indicates:

- ☐ Millirem, a unit of dose equivalent
- ☐ Millirad, a unit of dose
- ☐ Milliroentgen, a unit of exposure

29. High energy beta emitters (like P-32) are best shielded with a low atomic number (Z) material such as plexiglas or lucite rather than lead because:

    - ☐ They're lighter and less expensive than lead.
    - ☐ The beta particles are less likely to create bremsstrahlung radiation in low Z materials.
    - ☐ Lucite is more effective than lead in absorbing beta particles.
    - ☐ All of the above.

30. The largest man-made source of background radiation is from:

    - ☐ Smoke detectors
    - ☐ Televisions
    - ☐ Nuclear fallout
    - ☐ Medical uses (x-rays, nuclear medicine, radiation oncology, etc.)

31. Which of the following is (are) true for radiation exposure to an unborn child?

    - ☐ An unborn child is most sensitive during the first three months of pregnancy.
    - ☐ Radiation workers at NSU who are pregnant, or are considering becoming pregnant, should contact EHS Office for additional radiation safety information.
    - ☐ Pregnant workers need not be concerned with exposures to low energy beta emitters, (e.g. tritium).
    - ☐ All of the above.

III. Certification:

I have read and understand the material contained within this plan and my responsibilities as a user of radioactive materials and/or radiation-producing machines at NSU.

Signature: _____ ***Date:*** _____

APPENDIX Q Florida Bureau of Radiation Control Application

STATE OF FLORIDA
DEPARTMENT OF HEALTH
BUREAU OF RADIATION CONTROL
RADIOACTIVE MATERIALS SECTION
APPLICATION FOR RADIOACTIVE MATERIALS LICENSE

FLORIDA DEPARTMENT OF HEALTH

NON-HUMAN USE

INSTRUCTIONS - Complete Items 1 through 15 as applicable. **Use supplemental sheets where necessary.** Item 15 must be completed on all applications. **Mail three copies to:** Department of Health, Bureau of Radiation Control, Radioactive Materials Section, Bin C21, 4052 Bald Cypress Way, Tallahassee, FL 32399-1741.

1.a. NAME AND MAILING ADDRESS OF APPLICANT (institution, firm, company, person, etc.). TELEPHONE NO.: ( )	1.b. STREET ADDRESS(ES) AT WHICH RADIOACTIVE MATERIAL WILL BE USED, IF DIFFERENT FROM 1.A.
2.a. LICENSE FEE CATEGORY: 2.b. LICENSE FEE ENCLOSED: $ _____	3. THIS IS AN APPLICATION FOR: ___ a. NEW LICENSE ___ b. AMENDMENT TO LICENSE NO. _____ ___ c. RENEWAL OF LICENSE NO. _____
4. INDIVIDUAL USERS: Name individuals who will use or directly supervise use of radioactive material.	5. RADIATION SAFETY OFFICER (RSO): Name of person designated for the RSO position.

6. TRAINING AND EXPERIENCE IN RADIATION SAFETY.

a. FORMAL TRAINING IN RADIATION SAFETY: Describe the formal training for each individual named in Items 4 and 5, including principles and practices of radiation protection, radioactivity measurement, monitoring techniques and the use of instruments, mathematics and calculations basic to the use and measurement of radioactivity, and biological effects of radiation. Include the name of the person or institution providing the training, duration of training and when training was received, or attach a copy of a training certificate from an approved training course where applicable.

b. EXPERIENCE: Describe the work experience with radiation for each individual named in Items 4 and 5, including where the experience was obtained. Include a list of radioisotopes and the maximum activity of each use. Work experience or on-the-job training should be commensurate with the proposed use.

DH 1054, Edition 12/2000 (replaces 5/97 edition which may also be used)

7. RADIOACTIVE MATERIAL.		
a. ELEMENT AND MASS NUMBER	b. CHEMICAL AND/OR PHYSICAL FORM (if sealed sources, include manufacturer and model number).	c. MAXIMUM AMOUNT TO BE POSSESSED AT ANY ONE TIME (if sealed source(s), state number of sources and maximum activity per source).

8. DESCRIBE PURPOSE FOR WHICH RADIOACTIVE MATERIALS LISTED IN ITEM 7, ABOVE, WILL BE USED.
(if radioactive material is in the form of a sealed source, include the manufacturer and model number of the storage container and/or device in which the source will be stored and/or used).

9. RADIATION DETECTION INSTRUMENTS.

TYPE OF INSTRUMENTS (include manufacturer and model number of each)	NUMBER AVAILABLE	RADIATION DETECTED	SENSITIVITY RANGE (mR/hr)	USE (e.g., monitoring, surveying, measuring)

10. CALIBRATION OF INSTRUMENTS LISTED ABOVE.

☐ a. CALIBRATED BY SERVICE COMPANY
State the name, address and license number of the service company and the frequency of calibration of the device.

☐ b. CALIBRATED BY APPLICANT
Attach a separate sheet describing procedures, frequency and standards used for calibrating instruments.

11. PERSONNEL MONITORING DEVICES. Complete Items a, b, c, d. and e.

a. ☐ Film ☐ OSLD ☐ TLD b. ☐ Whole body ☐ Extremity

c. Radiation detected: ☐ Beta ☐ Gamma ☐ Neutron

d. Supplier: _____ e. Frequency of exchange: _____

2

12. FACILITIES AND EQUIPMENT. Describe facilities where radioactive material, including waste, will be used and/or stored. **Attach an annotated diagram of the areas of use and/or storage, including adjacent areas.** Describe equipment such as remote handling devices, storage containers, shielding, fume hoods, etc.

13. RADIATION PROTECTION PROGRAM. Describe the radiation protection program as appropriate for the material to be used, including general radiation safety procedures, emergency procedures and bioassay procedures. If the application includes a request for sealed sources, submit leak testing procedures, or if leak testing will be performed using a leak test kit, specify the manufacturer and model number of the kit and the name and radioactive materials license number of the individuals who will perform the analysis.

14. WASTE DISPOSAL. Describe the procedures for handling, storing and disposing of radioactive wastes (solid, liquid and/or gas). Name the commercial waste disposal service employed, if applicable. If sealed sources and/or devices will be returned to the manufacturer, so state.

15. CERTIFICATE.

The applicant and any official executing this certificate on behalf of the applicant named in Item 1, certify that this application has been prepared in accordance with Chapter 64E-5, Florida Administrative Code, and that all information contained herein, including any supplements attached hereto, is true and correct to the best of our knowledge and belief.

Certifying Official (signature)

Name (typed or printed)

Title

Date

WARNING: KNOWINGLY MAKING FALSE STATEMENTS TO A PUBLIC SERVANT IS A VIOLATION OF SECTION 837.06, FLORIDA STATUTES, AND IS PUNISHABLE BY FINE OR IMPRISONMENT.

3

APPENDIX R

INVENTORY OF RADIOACTIVE SEALED SOURCES & DEVICES

Licensee: _____ License No.: _____

Date of Inventory: _____ Radiation Safety Officer (or designee) Signature: _____

#	GL or SL	GAUGE MANUFACTURER & MODEL NO.	GAUGE SERIAL NO.	SOURCE MANUFACTURER & MODEL NO.	SOURCE SERIAL NO.	ISOTOPE & ACTIVITY	LOCATION	CONDITION
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Note: Listing "IN STORAGE" in the CONDITON column identifies sources/devices held in secured storage with no use anticipated prior to transfer/disposal.