RADIATION SAFETY MANUAL

WRIGHT STATE UNIVERSITY

DAYTON, OHIO

Emergency Information – Contact Wright State Police Dispatch for on-call Radiation Safety Officer from Environmental Health and Safety

Emergency Contact	Phone Number
Wright State Police Dispatch	937-775-2111 911 (off campus or land lines)
Environmental Health and Safety	937-775-2215 (EHS Main Office) or 937-775-4444 (Customer Care)

Environmental Health and Safety

Radiation Safety

047 Biological Sciences II

937-775-2215

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1 Plan Authority

Table 1. Plan Authority

AUTHORITY		DATE
Marjorie Markopoulos (original signature on file)	Director, Environmental Health and Safety	

2 Version History

Table 2. Version History

VERSION HISTORY			
Version	Description of Change	Author	Effective Date
Basic	Revised format and editorial updates	M.Markopoulos	2-22-2020
2	Minor format changes; updated URLs	M. Markopoulos	9-17-2020
2	Added Plan Authority, Version History, and Reference Document Sections	M. Markopoulos	9-17-2020
3	Updated record locations and retention schedule	M. Markopoulos	1-5-2021
3	Added sealed source introduction, receipt, approval, leak test and inventory frequency information	M. Markopoulos	1-5-2021

3 Reference Documents

Document	Title
	Access to Employee Records
	Ohio Revised Code Chapter 4167, "Public Employee Risk Reduction Program (PERRP).

If any process in this document conflicts with any document in OSHA Bloodborne Pathogen Stand this document shall be superseded by the OSHA Bloodborne Pathogen document. Any reference document external to OSHA shall be monitored by the Plan Owner for current versioning.

4 DEFINITIONS

TERM	DEFINITION
A_1	means the maximum activity of special form radioactive material permitted in a type A package. These values are listed in rule 3701:1-50-25 of the Administrative Code, or may be derived in accordance with the procedure prescribed in rule 3701:1-50-25 of the Administrative Code.
A_2	means the maximum activity of radioactive material, other than special form, low specific activity and surface contaminated object material, permitted in a type A package. These values are listed in rule 3701:1-50-25 of the Administrative Code, or may be derived in accordance with the procedure prescribed in rule 3701:1-50-25 of the Administrative Code.
Absorbed dose	means the energy imparted by ionizing radiation per unit mass of irradiated material. The units of absorbed dose are the gray, or Gy, and the rad.

Accelerator or charged particle accelerator	means any of a class of radiation generating equipment designed to electronically accelerate atomic or subatomic particles for subsequent bombardment of targets.
Accelerator-produced radioactive material	means any material made radioactive by a particle accelerator.
Activity	means the rate of disintegration or transformation or decay of radioactive material. The units of activity are the becquerel, or Bq, and the curie, or Ci.
Address of use	means the building or buildings that are identified on the license or registration and where the source of radiation may be received, used, prepared, or stored, except for temporary job sites.
Administrative controls	means mechanisms used to protect health and minimize damage to life and property through the use of written policies, procedures, instructions, training, observation of work practices, and related compliance audits
Administrative monetary penalty	means a monetary penalty assessed by the director under section 3748.05 of the Revised Code and in compliance with rules adopted thereunder, to emphasize the need for lasting remedial action and to deter future violations.
Adult	means an individual eighteen or more years of age.
Agreement state	means any state with which the United States nuclear regulatory commission or the atomic energy commission has entered into an effective agreement under subsection 274B of the Atomic Energy Act of 1954, 68 Stat. 919, 42 U.S.C. 2021, as amended (1978). Non-agreement state means any other state.
Airborne radioactive material	means radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.
Airborne radioactivity area	means a room, enclosure, or area in which airborne radioactive materials, composed wholly or partly of licensed material, exist in concentrations: (a) In excess of the derived air concentrations (DACs) specified in appendix C to rule 3701:1-38-12 of the Administrative Code, or (b) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 per cent of the annual limit on intake or twelve DAC-hours.
Air-purifying respirator	means a respirator with an air-purifying filter, cartridge, or canister that removes specific air contaminants by passing ambient air through the air-purifying element.
ALARA or "as low as is reasonably achievable"	means every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed or registered activity is undertaken, taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials and registered activities in the public interest.
Alert	means events may occur, are in progress, or have occurred that could lead to a release of radioactive material but that the release is not expected to require a response by off-site response organizations to protect persons off-site.
Annual limit on intake or "ALI"	means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 0.05 sievert (five rem) or a committed dose equivalent of 0.5 sievert (fifty rem) to any individual organ or tissue. ALI values for intake by ingestion and by inhalation of selected radionuclides are given in appendix C to rule 3701:1-38-12 of the Administrative Code.
Annually	means either (a) At intervals not to exceed one year; or (b) Once per year, at about the same time each year, plus or minus one month.

Area of use	means a portion of an address of use that has been set aside for the purpose of receiving, preparing, using, or storing sources of radiation.
Assigned protection factor or APF	means the expected workplace level of respiratory protection that would be provided by a properly functioning respirator or a class of respirators to properly fitted and trained users. Operationally, the inhaled concentration can be estimated by dividing the ambient airborne concentration by the APF.
Atmosphere-supplying respirator	means a respirator that supplies the respirator user with breathing air from a source independent of the ambient atmosphere, and includes supplied air respirators, or SARs, and self-contained breathing apparatus, or SCBA, units.
Atomic energy commission or AEC	means the federal agency created by the Atomic Energy Act of 1954, 68 Stat. 919, 42 U.S.C. 2011, as amended (1964), and was the predecessor agency to the current United States nuclear regulatory commission.
Background radiation	means radiation from cosmic sources; naturally occurring radioactive materials, including radon, except as a decay product of source or special nuclear material, and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past nuclear accidents such as Chernobyl that contribute to background radiation and are not under the control of the licensee. "Background radiation" does not include radiation from radioactive materials regulated by the department.
Becquerel or "Bq"	means the SI unit of activity. One becquerel is equal to one disintegration per second.
Bioassay or "radiobioassay"	means the determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement, in vivo counting, or by analysis and evaluation of materials excreted or removed from the human body.
Byproduct material	means (a) Any radioactive material, except special nuclear material, yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear materials; or (b) The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from solution extraction processes. Underground ore bodies depleted by such solution extraction do not constitute byproduct material within the definition.
Chelating agent	means a chemical compound or mixture that enhances the removal of radioactive material from the body, water or similar applications. Typical chelating agents include amine polycarboxylic acids such as EDTA or DTPA; hydroxy-carboxylic acids; and polycarboxylic acids such as citric acid, carbolic acid, and gluconic acid.
Chiropractor	means an individual licensed by the state of Ohio to practice chiropractic medicine pursuant to Chapter 4734. of the Revised Code.
Class or "lung class" or "inhalation class"	means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for class D, days, of less than ten days, for class W, weeks, from ten to one hundred days, and for class Y, years, of greater than one hundred days.
Collective dose	means the sum of the individual doses received in a given period of time by a specified population from exposure to a specified source of radiation.
Commencement of construction	means taking any action defined as "construction" or any other activity at the site of a facility subject to the rules promulgated pursuant to Chapter 3748. of the Revised Code that has a reasonable nexus to radiological health and safety
Committed dose equivalent" or "$H_{T,50}$"	means the dose equivalent to organs or tissues of reference, T, that will be received from an intake of radioactive material by an individual during the fifty year period following the intake.

Committed effective dose equivalent" or "$H_{E,50}$"	means the sum of the products of the weighting factors applicable to each of the body organs or tissues, WT, that are irradiated and the committed dose equivalent to each of these organs or tissues (HE,50 = WTHT,50).
Consortium	means an association of medical use licensees and a PET radionuclide production facility in the same geographical area that jointly own or share in the operation and maintenance cost of the PET radionuclide production facility that produces PET radionuclides for use in producing radioactive drugs within the consortium for noncommercial distributions among its associated members for medical use. The PET radionuclide production facility within the consortium must be located at an educational institution or a medical facility.
Constraint or "dose constraint"	means a value above which specified licensee actions are required.
Construction	means the installation of foundations, or in-place assembly, erection, fabrication, or testing for any structure, system, or component of a facility or activity subject to the rules promulgated pursuant to Chapter 3748. of the Revised Code that are related to radiological safety or security. The term "construction" does not include: (a) Changes for temporary use of the land for public recreational purposes; (b) Site exploration, including necessary borings to determine foundation conditions or other preconstruction monitoring to establish background information related to the suitability of the site, the environmental impacts of construction or operation, or the protection of environmental values; (c) Preparation of the site for construction of the facility, including clearing of the site, grading, installation of drainage, erosion and other environmental mitigation measures, and construction of temporary roads and borrow areas; (d) Erection of fences and other access control measures that are not related to the safe use of, or security of, radiological materials subject to the rules promulgated pursuant to Chapter 3748. of the Revised Code; (e) Excavation; (f) Erection of support buildings (e.g. construction equipment storage sheds, warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and office buildings) for use in connection with the construction of the facility; (g) Building of service facilities (e.g. paved roads, parking lots, railroad spurs, exterior utility and lighting systems, potable water systems, sanitary sewerage treatment facilities, and transmission lines); (h) Procurement or fabrication of components or portions of the proposed facility occurring at other than the final, in-place location at the facility; or (i) Taking any other action that has no reasonable nexus to radiological health and safety.
Controlled area	means an area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee or registrant for any reason.
Critical group	means the group of individuals reasonably expected to receive the greatest exposure to residual radioactivity for any applicable set of circumstances.
Curie" or "Ci"	means a unit of activity. One curie equals 3.7 x 1010 disintegrations per second equals 3.7 x 1010 becquerels equals 2.22 x 1012 disintegrations per minute.
Cyclotron	means a particle accelerator in which the charged particles travel in an outward spiral or circular path. A cyclotron accelerates charged particles at energies usually in excess of ten megaelectron volts and is commonly used for production of short half-life radionuclides for medical use.
Declared pregnant woman	means a woman who has voluntarily informed the licensee or registrant, in writing, of her pregnancy and the estimated date of conception. The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.
Decommission	means to safely remove any licensed operation from service and reduce residual radioactivity to a level that permits release of the licensee's property for unrestricted use and termination of the license.

Dedicated check source	means a radioactive source that is used to assure the consistent performance of a radiation detection or measurement device over several months or years.
Deep dose equivalent" or "H_d"	applies to external whole body exposure, and means the dose equivalent at a tissue depth of one centimeter, one thousand milligram per square centimeter.
Demand respirator	means an atmosphere-supplying respirator that admits breathing air to the facepiece only when a negative pressure is created inside the facepiece by inhalation.
Dentist	means an individual licensed by the state of Ohio to practice dentistry under Chapter 4715. of the Revised Code.
Department	means the Ohio department of health.
Depleted uranium	means uranium containing less uranium-235 than the naturally occurring distribution of uranium isotopes.
Derived air concentration or DAC	means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of two thousand hours under conditions of light work, results in an intake of one ALI. The condition of light work is inhaling 1.2 cubic meters of air per hour for two thousand hours in a year. DAC values are given in appendix C to rule 3701:1-38-12 of the Administrative Code.
Derived air concentration-hour or DAC-hour	means the product of the concentration of radioactive material in air, which is expressed as a fraction or multiple of the derived air concentration for each radionuclide, and the time of exposure to that radionuclide, in hours. A licensee or registrant may take two thousand DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 0.05 Sv (five rem).
Direct reading dosimeter	Direct reading dosimeter" means a device that measures radiation dose that does not require another device to read the measured radiation dose. Examples of direct reading dosimeters include pocket dosimeters and electronic dosimeters.
Director	means the director of health or a designee or authorized representative of the director.
Discipline	means a branch of knowledge or of teaching.
Discrete source	means a radionuclide that has been processed so that its concentration within a material has been purposely increased for use for commercial, medical, or research activities.
Disposable respirator	means a respirator for which maintenance is not intended and that is designed to be discarded after excessive breathing resistance, sorbent exhaustion, physical damage, or end-of service-life renders it unsuitable for use. Examples of this type of respirator are a disposable half-mask respirator or a disposable escape-only self-contained breathing apparatus.
Dose" or "radiation dose"	is a generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined in other paragraphs of this rule.
Dose equivalent" or "H_T"	(57) "Dose equivalent" or "HT" 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 sievert and rem.
Dose limits" or "limits"	means the permissible upper bounds of radiation doses established in accordance with these regulations but excludes background radiation and medical exposure.
Dosimetry processor	means a person that processes and evaluates individual monitoring devices in order to determine the radiation dose delivered to the monitoring devices.
Effective dose equivalent or H_E	means the sum of the products of the dose equivalent to each organ or tissue, HT, and the weighting factor, WT, applicable to each of the body organs or tissues that are irradiated: (HE = Î£WTHT).
Embryo" or "fetus"	means the developing human organism from conception until time of birth.
Engineering controls	means mechanisms used to protect health and minimize damage to life and property through engineering specifications, design, and construction of the product or facility including all of the security and safety features. This includes, but is not limited to, auxiliary security and safety features such as additional external shielding, barriers, and operational interlocks with associated processes.

Entrance or access point	means any opening through which an individual or extremity of an individual could gain access to radiation areas or to licensed radioactive materials or registered radiation generating equipment. This includes entry or exit portals f sufficient size to permit human entry, irrespective of their intended use.
Explosive material	means any chemical compound, mixture or device which produces a substantial instantaneous release of gas and heat spontaneously or by contact with sparks or flame.
Exposure	means being exposed to sources of ionizing radiation.
External dose	means that portion of the dose equivalent received from radiation sources outside the body.
Extremity	means hand, elbow, arm below the elbow, foot, knee, or leg below the knee.
Eye dose equivalent	means the same as lens dose equivalent.
Facility	means all buildings, equipment, structures and other stationary items that, in addition to the meaning defined in division (H) of section 3748.01 of the Revised Code, are: (a) Located on a single site or on contiguous or adjacent sites and are operated by the same person and have common corporate or business interests; or (b) Portions of a building or structure which are operated by the same person and have common corporate or business interests.
Filtering facepiece" or "dust mask"	means a negative pressure particulate respirator with a filter as an integral part of the facepiece or with the entire facepiece composed of the filtering medium, not equipped with elastomeric sealing surfaces and adjustable straps.
Fissile material	means the radionuclides uranium-233, uranium-235, plutonium-239, and plutonium-241, or any combination of these radionuclides. Fissile material means the fissile nuclides themselves, not material containing fissile nuclides. Unirradiated natural uranium and depleted uranium and natural uranium or depleted uranium that has been irradiated in thermal reactors only, are not included in this definition. Certain exclusions from fissile material controls are provided in rule 3701:1-50-13 of the Administrative Code.
Fit factor	means quantitative estimate of the fit of a particular respirator to a specific individual, and typically estimates the ratio of the concentration of a substance in ambient air to its concentration inside the respirator when worn.
Fit test	means the use of a protocol to qualitatively or quantitatively evaluate the fit of a respirator on an individual.
Generally applicable environmental radiation standards	means standards issued by the United States environmental protection agency under the authority of the Atomic Energy Act of 1954, 68 Stat. 919, 42 U.S.C. 2011, as amended (2005), that impose limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.
Gray or Gy	means the SI unit of absorbed dose. One gray is equal to an absorbed dose of one joule per kilogram (one hundred rads).
Handler	(means a facility that handles sources of radiation unless possession is solely (81) "Individual" means any human being. (82) "Individual monitoring" means (a) The assessment of dose equivalent by the use of devices designed to be worn by an individual; (b) The assessment of committed effective dose equivalent by bioassay or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e. DAC-hours; or (c) The assessment of dose equivalent by the use of survey data. (83) "Individual monitoring devices" means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges; thermoluminescent dosimeters; optically stimulated luminescent dosimeters; pocket ionization chambers; and personal air sampling devices.

	(84) "Industrial radiography" means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of radioactive material or radiation-generating equipment. (85) "Internal dose" means that portion of the dose equivalent received from radioactive material taken into the body. (86) "Irradiator" means a facility that uses radioactive sealed sources for the irradiation of objects or materials and in which radiation dose rates exceeding five grays (five hundred rads) per hour exist at one meter from the sealed radioactive source in air or water, as applicable for the irradiator type, but does not include irradiators in which both the sealed source and the area subject to irradiation are contained within a device and are not accessible to personnel.
Hazardous waste	means those wastes designated as hazardous by rule 3745-51-03 of the Administrative Code.
Helmet	means a rigid respiratory inlet covering that also provides head protection against impact and penetration.
High radiation area	means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of one millisievert (0.1 rem) in one hour at thirty centimeters from the radiation source or thirty centimeters from any surface that the radiation penetrates.
Hood	means a respiratory inlet covering that completely covers the head and neck and may also cover portions of the shoulders and torso.
Individual	means any human being.
Individual monitoring	means (a) The assessment of dose equivalent by the use of devices designed to be worn by an individual; (b) The assessment of committed effective dose equivalent by bioassay or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e. DAC-hours; or (c) The assessment of dose equivalent by the use of survey data.
Individual monitoring devices	means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges; thermoluminescent dosimeters; optically stimulated luminescent dosimeters; pocket ionization chambers; and personal air sampling devices.
Industrial radiography	means the examination of the structure of materials by nondestructive methods, utilizing sealed sources of radioactive material or radiation-generating equipment.
Internal dose	means that portion of the dose equivalent received from radioactive material taken into the body.
Irradiator	means a facility that uses radioactive sealed sources for the irradiation of objects or materials and in which radiation dose rates exceeding five grays (five hundred rads) per hour exist at one meter from the sealed radioactive source in air or water, as applicable for the irradiator type, but does not include irradiators in which both the sealed source and the area subject to irradiation are contained within a device and are not accessible to personnel.
Lens dose equivalent" or "eye dose equivalent"	means the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeters; i.e. three hundred milligrams per square centimeter.
License	means a license issued by the nuclear regulatory commission, the director, or another agreement state in accordance with rules adopted by those organizations.
Licensee	means a person to whom a license is issued.
Licensed activity	means an activity authorized by a radioactive material license which is essential to achieving the purpose for which the license was issued or amended.
Licensed material	means radioactive material received, possessed, used, transferred or disposed of under a general or specific license.

Loose-fitting facepiece	means a respiratory inlet covering that is designed to form a partial seal with the face.
Lost or missing licensed source of radiation	means a licensed source of radiation whose location is unknown. It includes material that has been shipped but has not reached its destination and whose location cannot be readily traced in the transportation system.
Low-level radioactive waste or LLRW also low-level waste or LLW	means radioactive waste which is not high-level radioactive waste, spent nuclear fuel, NARM, or byproduct material as defined in section 11 E. (2) of the Atomic Energy Act of 1954 68 Stat. 919, 42 U.S.C. 2011, as amended (2005), but is radioactive material that the United States nuclear regulatory commission classifies as low-level radioactive waste.
Low specific activity material" or "LSA"	means radioactive material with limited specific activity which is nonfissile or is excepted under rule 3701:1-50-13 of the Administrative Code, and which satisfies the descriptions and limits set forth below. Shielding materials surrounding the LSA material may not be considered in determining the estimated average specific activity of the package contents. LSA must be in one of three groups: (a) LSA - I. (i) Uranium and thorium ores, concentrates of uranium and thorium ores, and other ores containing naturally occurring radioactive radionuclides that are intended to be processed for the use of these radionuclides; (ii) Natural uranium, depleted uranium, natural thorium or their compounds or mixtures, provided they are unirradiated and in solid or liquid form; (iii) Radioactive material other than fissile material, for which the A2 value is unlimited; or (iv) Other radioactive material in which the activity is distributed throughout and the estimated average specific activity does not exceed thirty times the value for exempt material activity concentration determined in accordance with rule 3701:1-50-25 of the Administrative Code. (b) LSA-II. (i) Water with tritium concentration up to 0.8 terabecquerels per liter (twenty curies per liter); or (ii) Other material in which the activity is distributed throughout and the estimated average specific activity does not exceed (10-4 A2) per gram for solids and gases, and (10-5 A2) per gram for liquids. (c) LSA-III. Solids (e.g., consolidated wastes, activated materials), excluding powders, that satisfy the requirements of 10 C.F.R. 71.77 (as published in the January 1, 2017, Code of Federal Regulations), in which: (i) The radioactive material is distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc.); (ii) The radioactive material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that even under loss of packaging, the loss of radioactive material per package by leaching, when placed in water for seven days, would not exceed (0.1 x A2); and (iii) The estimated average specific activity of the solid, excluding any shielding material, does not exceed 0.002 x A2) per gram.
Management	means the chief executive officer or other individual having the authority to manage, direct, or administer the licensee's activities, or those persons' delegate or delegates.
Medical institution	means an organization in which more than one medical discipline is practiced.
Medical use	means the intentional internal or external administration of radioactive material or the radiation therefrom to patients or human research subjects under the supervision of an authorized user.
Member of the public	means any individual except when that individual is receiving an occupational dose.
Minor	means an individual less than eighteen years of age.

Monitoring or radiation monitoring or radiation protection monitoring	means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses.
NARM or naturally occurring or accelerator-produced radioactive material	means naturally occurring or accelerator-produced radioactive material, including naturally occurring material that is technologically enhanced, and those nuclides that are generated in a charged particle accelerator, but does not include source material, byproduct material, or special nuclear material.
NARM licensing state	means any state with regulations equivalent to the suggested state regulations for control of radiation relating to, and an effective program for, the regulatory control of NARM and which has been granted final designation by the conference of radiation control program directors, inc.
Nationally tracked source	means a sealed source containing a quantity equal to or greater than "Category 1" or "Category 2" levels of any radioactive material listed in the appendix to rule 3701:1-38-25 of the Administrative Code. In this context a sealed source is defined as radioactive material that is sealed in a capsule or closely bonded, in a solid form and which is not exempt from regulatory control. It does not mean material encapsulated solely for disposal, or nuclear material contained in any fuel assembly, subassembly, fuel rod, or fuel pellet. "Category 1" nationally tracked sources are those containing radioactive material at a quantity equal to or greater than the "Category 1" threshold. "Category 2" nationally tracked sources are those containing radioactive material at a quantity equal to or greater than the "Category 2" threshold but less than the "Category 1" threshold.
Negative pressure respirator or tight fitting respirator	means a respirator in which the air pressure inside the facepiece is negative during inhalation with respect to the ambient air pressure outside the respirator. (106) "Nonstochastic effect" or "deterministic effect" means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect. (107) "NORM" or "naturally occurring radioactive material" means any nuclide that is radioactive in its natural physical state, but does not include source material, byproduct material, or special nuclear material. (108) "Normal form radioactive material" means radioactive material that has not been demonstrated to qualify as special form radioactive material. (109) "Nuclear regulatory commission" means the federal agency established by Title II of the Energy Reorganization Act of 1974, 88 Stat. 1233, 42 U.S.C.A. 5801, as amended (2005), comprising the members of the commission and all offices, employees, and representatives authorized to act in any case or matter related to licensing and related regulatory function previously assigned to the AEC.
Nonstochastic effect or deterministic effect	means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect.
NORM or naturally occurring radioactive material	means any nuclide that is radioactive in its natural physical state, but does not include source material, byproduct material, or special nuclear material.
Normal form radioactive material	means radioactive material that has not been demonstrated to qualify as special form radioactive material.

Nuclear regulatory commission	means the federal agency established by Title II of the Energy Reorganization Act of 1974, 88 Stat. 1233, 42 U.S.C.A. 5801, as amended (2005), comprising the members of the commission and all offices, employees, and representatives authorized to act in any case or matter related to licensing and related regulatory function previously assigned to the AEC.
Occupational dose	means the dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from exposures to individuals administered radioactive materials and released in accordance with rule 3701:1-58-30 of the Administrative Code or equivalent United States nuclear regulatory commission or agreement state regulations, from voluntary participation in medical research programs, or as a member of the public.
Package	means the packaging together with its radioactive contents as presented for transport. (a) Fissile material package or type AF package, type BF package, type B(U)F package, or type B(M)F package means a fissile material packaging together with its fissile material contents. (b) Type A package means a type A packaging together with its radioactive contents. A type A package is defined and must comply with the United States department of transportation regulations in 49 C.F.R. 173 (as published in the October 1, 2014, Code of Federal Regulations). (c) Type B package means a type B packaging together with its radioactive contents. On approval, a type B package design is designated by the United States nuclear regulatory commission as B(U) unless the package has a maximum normal operating pressure of more than seven hundred kilopascals (one hundred pounds per square inch) gauge or a pressure relief device that would allow the release of radioactive material to the environment under the tests specified in 10 C.F.R. 71.73 (hypothetical accident conditions) (as published in the January 1, 2015, Code of Federal Regulations), in which case it will receive a designation B(M). B(U) refers to the need for unilateral approval of international shipments; B(M) refers to the need for multilateral approval of international shipments. There is no distinction made in how packages with these designations may be used in domestic transportation. To determine their distinction for international transportation, see United States department of transportation regulations in 49 C.F.R. 173 (as published in the October 1, 2014 Code of Federal Regulations). A type B package approved before September 6, 1983, was designated only as type B. Limitations on its use are specified in 10 C.F.R. 71.19 (as published in the January 1, 2015, Code of Federal Regulations).
Packaging	means the assembly of components necessary to ensure compliance with the packaging requirements of rule 49 C.F.R. 173 Subpart I (as published in the October 1, 2014, Code of Federal Regulations). It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks. The vehicle, tie-down system and auxiliary equipment may be designated as part of the packaging.
Particle accelerator	means any machine capable of accelerating electrons, protons, deuterons, or other charged particles in a vacuum and of discharging the resultant particulate or other radiation into a medium at energies usually in excess of one megaelectron volt. For purposes of this definition, "accelerator" is an equivalent term.
Person	means any individual, corporation, association, business enterprise, or other legal entity either public or private and any legal successor, representative, agent, or agency of that individual, corporation, association, business enterprise, or other legal entity. Person also includes the United States, states, political subdivisions of states, and any department, agency, or instrumentality of the United States or a state, except the U.S. department of energy or the U.S. nuclear regulatory commission where the state regulation of radioactive material by either of those agencies is prohibited by federal law.

Personnel dosimeter	means a device that measures radiation dose that is processed and evaluated by an accredited "National Voluntary Laboratory Accreditation Program" (NVLAP) processor. Examples of personnel dosimeters include film badges, thermo-luminescent dosimeters (TLD), and optically stimulated luminescence (OSL) dosimeters.
Pharmacist	means a person who is licensed by the state of Ohio to practice pharmacy pursuant to Chapter 4731. of the Revised Code.
Physician	means a person who is licensed pursuant to Chapter 4731. of the Revised Code to practice medicine or surgery or osteopathic medicine or surgery.
Planned special exposure	means an infrequent exposure to radiation, separate from and in addition to the annual dose limits.
Podiatrist	means an individual licensed by the state of Ohio to practice podiatry pursuant to Chapter 4731. of the Revised Code.
Positive pressure respirator	means a respirator in which the pressure inside the respiratory inlet covering exceeds the ambient air pressure outside the respirator.
Positron Emission Tomography (PET) radionuclide production facility	means a facility operating a cyclotron or accelerator for the purpose of producing PET radionuclides.
Powered air-purifying respirator or PAPR	means an air-purifying respirator that uses a blower to force the ambient air through air purifying elements to the inlet covering.
Pressure demand respirator	means a positive pressure atmosphere supplying respirator that admits breathing air to the facepiece when the positive pressure is reduced inside the facepiece by inhalation.
Public dose	means the dose received by a member of the public from exposure to radiation and/or radioactive material released by the licensee, or to any other source of radiation under the control of a licensee or registrant. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposures to individuals administered radioactive materials and released in accordance with rule 3701:1-58-30 of the Administrative Code or equivalent United States nuclear regulatory commission or agreement state regulations, or from voluntary participation in medical research programs.
Pyrophoric material	means any liquid that ignites spontaneously in dry or moist air at or below 54.4 degrees celsius (one hundred thirty degrees fahrenheit). A pyrophoric solid is any solid material, other than one classed as an explosive, which under normal conditions is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation, handling, or disposal hazard. Included are spontaneously combustible and water-reactive materials.
Qualitative fit test or QLFT	means a pass/fail fit test to assess the adequacy of respirator fit that relies on the individual's response to the test agent.
Quality factor or Q	means the modifying factor, as listed in paragraphs (A) and (B) of rule 3701:1-38-11 of the Administrative Code, that is used to derive dose equivalent from absorbed dose.
Quantitative fit test or QNFT	means an assessment of the adequacy of respirator fit by numerically measuring the amount of leakage into the respirator.
Quarter or quarterly	means a period of time equal to one-fourth of the year observed by the licensee or registrant, approximately thirteen consecutive weeks, providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.
Rad	means the special unit of radiation absorbed dose. One rad is equal to an absorbed dose of one hundred ergs per gram, or 0.01 joule per kilogram, or 0.01 gray.

Radiation or ionizing radiation	means alpha particles, beta particles, gamma rays, x-rays, neutrons, high speed electrons, high speed protons, and other particles capable of producing ions. Radiation does not include nonionizing radiation, such as radio or microwaves, or visible, infrared or ultraviolet light.
Radiation area	(means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.05 millisievert (0.005 rem) in one hour at thirty centimeters from the source of radiation or from any surface that the radiation penetrates.
Radiation-generating equipment or RGE	means any manufactured product or device, or component of such a product or device, or any machine or system that during operation can generate or emit radiation, except those that emit radiation only from radioactive material. "Radiation-generating equipment" does not include either of the following: (a) Diathermy machines; (b) Microwave ovens, including food service microwave ovens used for commercial and industrial uses, television receivers, electric lamps, and other household appliances and products that generate very low levels of radiation.
Radiation Safety Officer or RSO	means an individual designated by the licensee who has the knowledge and responsibility for the overall radiation safety program at the facility, to include the implementation of the daily radiation safety operations and compliance with the rules.
Radioactive material	means any solid, liquid or gaseous material that emits ionizing radiation spontaneously. "Radioactive material" includes accelerator-produced and naturally occurring radioactive materials and byproduct, source, and special nuclear material.
Radioactive waste	means waste containing regulated radioactive material.
Radioactivity	means the transformation of unstable atoms by the emission of radiation.
Radiography	means the same as industrial radiography.
Reference man	means a hypothetical aggregation of human physical and physiological characteristics arrived at by international consensus. These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological insult to a common base.
Registrant	means a person required by Chapter 3748. of the Revised Code to register radiation-generating equipment with the director.
Rem	means the special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rads multiplied by the quality factor (one rem = 0.01 Sv).
Research and development	means (a) Theoretical analysis, exploration, or experimentation; or (b) The extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials and processes. "Research and development" does not include the internal or external administration of sources of radiation to human beings.
Residual radioactivity	means radioactivity in structures, materials, soils, groundwater, and other media at a site resulting from activities under the licensee's control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 C.F.R. 20 (as published in the January 1, 2015, Code of Federal Regulations).
Respiratory protective equipment or device	means an apparatus, such as a respirator, used to reduce the individual's intake of airborne radioactive materials.
Restricted area	means an area access to which is limited by the licensee or registrant for the purpose of protecting individuals against undue risks from exposure to sources of radiation.

	Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.
Roentgen	means the amount of gamma or x-rays required to produce ions resulting in a charge of 0.000258 coulombs per kilogram of air under standard conditions.
Sanitary sewerage	means a system of public sewers for carrying off wastewater and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by the licensee.
Sealed source	means radioactive material that is encased in a manner designed to prevent leakage or escape of the radioactive material.
Sealed source and device registry	means the national registry that contains all the registration certificates, generated by both the United States nuclear regulatory commission and the agreement states, that summarize the radiation safety information for the sealed sources and devices and describe the licensing and use conditions approved for the product.
Seismic area	means any area where the probability of a horizontal acceleration in rock of more than 0.3 times the acceleration of gravity in two hundred fifty years is greater than ten per cent, as designated by the United States geological survey.
Self-contained breathing apparatus or SCBA	means an atmosphere-supplying respirator for which the breathing air source is designed to be carried by the user.
Shallow dose equivalent or HS	means 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, or seven milligrams per square centimeter.
Sievert or Sv	means 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. One sievert equals one hundred rem.
Site area emergency	means events may occur, are in progress, or have occurred that could lead to a significant release of radioactive material and that could require a response by off-site response organizations to protect persons off-site.
Site boundary	means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee or registrant.
Site closure and stabilization	means those actions that are taken upon completion of operations that prepare a disposal site for custodial care and that assure that the disposal site will remain stable and will not need ongoing active maintenance.
Source material	means uranium, thorium, or any combination thereof in any physical or chemical form, or any ores that contain by weight at least one-twentieth of one per cent (0.05 per cent) of uranium, thorium, or any combination thereof. Source material does not include special nuclear material.
Sources of radiation	means radioactive material or radiation generating equipment.
Special form radioactive material	means radioactive material that satisfies the following conditions: (a) It is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule; (b) The piece or capsule has at least one dimension not less than five millimeters (0.2 inch); and (c) It satisfies the test requirements specified by the United States nuclear regulatory commission in 10 C.F.R. 71.75 (as published in the January 1, 2017, Code of Federal Regulations). A special form encapsulation designed in accordance with the United States nuclear regulatory commission requirements identified in 10 C.F.R. 71.4, in effect on June 30, 1983, and constructed prior to July 1, 1985; a special form encapsulation designed in accordance with the requirements of 10 C.F.R. 71.4 in effect on March 31, 1996, and constructed before April 1, 1998; and special form material that was successfully tested before September 10, 2015 in accordance with the requirements of 10 C.F.R. 71.75(d) of this section in effect before September 10, 2015 may continue to

	be used. Any other special form encapsulation must meet the specifications of this definition.
Special nuclear material	means either of the following: (a) Plutonium, uranium-233, uranium enriched in the isotope 233, or in the isotope 235, and any other material that the United States nuclear regulatory commission determines to be special nuclear material, but does not include source material pursuant to section 51 of the Atomic Energy Act of 1954, 68 Stat 919, 42 USCA 2071, as amended (2005). (b) Any material artificially enriched by any of the foregoing but does not include source material.
Special nuclear material in quantities not sufficient to form a critical mass	means uranium enriched in the isotope uranium-235 in quantities not exceeding three hundred fifty grams of contained uranium-235; uranium-233 in quantities not exceeding two hundred grams; plutonium in quantities not exceeding two hundred grams; or any combination of them in accordance with the following formula: for each kind of special nuclear material, determine the ratio between the quantity of that special nuclear material and the quantity specified above for the same kind of special nuclear material. The sum of such ratios for all of the kinds of special nuclear material in combination shall not exceed unity.
Stochastic effect	means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.
Supplied-air respirator or SAR or airline respirator	means an atmosphere-supplying respirator for which the source of breathing air is not designed to be carried by the user.
Surface contaminated object or SCO	means a solid object that is not itself classed as radioactive material, but which has radioactive material distributed on any of its surfaces. SCO must be in one of two groups with surface activity not exceeding the following limits: (a) SCO-I: a solid object on which: (i) The non-fixed contamination on the accessible surface averaged over three hundred square centimeters, or the area of the surface if less than three hundred square centimeters, does not exceed four becquerels per square centimeter (10-4 microcurie per square centimeter) for beta and gamma and low toxicity alpha emitters, or 0.4 becquerels per square centimeter 10-5 microcurie per square centimeter) for all other alpha emitters; (ii) The fixed contamination on the accessible surface averaged over three hundred square centimeters, or the area of the surface if less than three hundred square centimeters, does not exceed forty thousand becquerels per square centimeter (one microcurie per square centimeter) for beta and gamma and low toxicity alpha emitters, or four thousand becquerels per square centimeter (0.1 microcurie per square centimeter) for all other alpha emitters; and (iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over three hundred square centimeters, or the area of the surface if less than three hundred square centimeters, does not exceed forty thousand becquerels per square centimeter (one microcurie per square centimeter) for beta and gamma and low toxicity alpha emitters, or four thousand becquerels per square centimeter (0.1 microcurie per square centimeter) for all other alpha emitters. (b) SCO-II: a solid object on which the limits for SCO-I are exceeded and on which: (i) The non-fixed contamination on the accessible surface averaged over three hundred square centimeters, or the area of the surface if less than three hundred square centimeter, does not exceed four hundred becquerels per square centimeter (10-2 microcurie per square centimeter) for beta and gamma and low toxicity alpha emitters, or forty becquerels per square centimeter (10-3 microcurie per square centimeter) for all other alpha emitters; (ii) The fixed contamination on the accessible surface averaged over three hundred square centimeters, or the area of the surface if less than three hundred square centimeters, does not exceed eight hundred thousand becquerels per square centimeter (twenty microcuries per square centimeter) for beta and gamma and low toxicity alpha

	emitters, or eighty thousand becquerels per square centimeter (two microcuries per square centimeter) for all other alpha emitters; and (iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over three hundred square centimeters, or the area of the surface if less than three hundred square centimeters, does not exceed eight hundred thousand becquerels per square centimeter (twenty microcuries per square centimeter) for beta and gamma and low toxicity alpha emitters, or eighty thousand becquerels per square centimeter (two microcuries per square centimeter) for all other alpha emitters.
Survey	means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material, or the sources of radiation and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.
Tight-fitting facepiece	means a respiratory inlet covering that forms a complete seal with the face.
Total effective dose equivalent or TEDE	means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
Transport index	means the dimensionless number, rounded up to the next tenth, placed on the label of a package, to designate the degree of control to be exercised by the carrier during transportation. The transport index is the number determined by multiplying the maximum radiation level in millisievert per hour at one meter (3.3 feet) from the external surface of the package by one hundred, which is equivalent to the maximum radiation level in millirem per hour at one meter (3.3 feet).
Type A quantity	means a quantity of radioactive material, the aggregate radioactivity of which does not exceed A1 for special form radioactive material, or A2 for normal form radioactive material, where A1 and A2 are given in rule 3701:1-50-25 of the Administrative Code.
Type B quantity	means a quantity of radioactive material greater than a type A quantity.
Type B package	is defined under "Package."
United States department of energy	means the department of energy established by the Department of Energy Organization Act, PL 95-91, 91 Stat. 565 (1977), 42 U.S.C. 7101 et seq., as amended (2006), to the extent that the department of energy or its duly authorized representatives, exercises functions formerly vested in the United States atomic energy commission, its chairman, members, officers and components and transferred to the United States energy research and development administration and to the administrator thereof pursuant to Sections 104(b) to (d) of the Energy Reorganization Act of 1974, PL 93-438, 88 Stat. 1233 at 1237 (1974), 42 U.S.C. 5814 and retransferred to the secretary of energy pursuant to Section 301(a) of the Department of Energy Organization Act, PL 95-91, 91 Stat. 565 at 577-578 (1977), 42 U.S.C. 7151.
Unrestricted area or uncontrolled area	means any area, access to which is neither restricted nor controlled by the licensee or registrant.
User seal check or fit check	means an action conducted by the respirator user to determine if the respirator is properly seated to the face. Examples include negative pressure check, positive pressure check, irritant smoke check, or isoamyl acetate check.
Very high radiation area	means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving an absorbed dose in excess of five gray (five hundred rad) in one hour at one meter from a source of radiation or from any surface that the radiation penetrates. At very high doses received at high dose rates, units of absorbed dose, gray and rad, are appropriate, rather than units of dose equivalent, sievert and rem.
Veterinarian	means an individual licensed by the state of Ohio to practice veterinary medicine pursuant to Chapter 4741. of the Revised Code.

<table>
<tr><td>Waste</td><td>means those low-level radioactive wastes containing source, special nuclear, or byproduct material that are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level radioactive waste means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in paragraph (A)(26) (b) of this rule, or byproduct material as defined in section 11 E. (3) and (4) of the Atomic Energy Act of 1954, 68 Stat. 919, 42 USC 2014, as amended (2005).</td></tr>
<tr><td>Week</td><td>means seven consecutive days starting on Sunday.</td></tr>
<tr><td>Weighting factor - WT</td><td>for an organ or tissue, (T), is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose equivalent, the values of WT are:
<table>
<tr><td colspan="2">Organ dose weighting factors</td></tr>
<tr><td>Organ or tissue</td><td>WT</td></tr>
<tr><td>Gonads</td><td>0.25</td></tr>
<tr><td>Breast</td><td>0.15</td></tr>
<tr><td>Red bone marrow</td><td>0.12</td></tr>
<tr><td>Lung</td><td>0.12</td></tr>
<tr><td>Thyroid</td><td>0.03</td></tr>
<tr><td>Bone surfaces</td><td>0.03</td></tr>
<tr><td>Remainder</td><td>0.30a</td></tr>
<tr><td>Whole body</td><td>1.00b</td></tr>
</table>
\a\0.30 results from 0.06 for each of five "remainder" organs, excluding the skin and the lens of the eye, that receive the highest doses.
\b\ for the purpose of weighting the external whole body dose (for adding it to the internal dose) a single weighting factor, WT = 1.0, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued.</td></tr>
<tr><td>Whole body</td><td>means for purposes of external exposure, head; trunk, including male gonads; arms above the elbow; legs above the knee.</td></tr>
<tr><td>Worker</td><td>means an individual engaged in activities licensed or registered by the department and controlled by a licensee or registrant, but does not include the licensee or registrant.</td></tr>
<tr><td>Working level or WL</td><td>means any combination of short-lived radon decay products (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in one liter of air that will result in the ultimate emission of 1.3 x 105 million electron volts alpha particle energy.</td></tr>
<tr><td>Working level month or WLM</td><td>means a cumulative exposure to one working level for one hundred seventy hours. (Two thousand working hours per year/twelve months per year equals approximately one hundred seventy hours per month.)</td></tr>
<tr><td>Year</td><td>means the period of time beginning in January used to determine compliance with the provisions of this rule. The licensee or registrant may change the starting date of the year used to determine compliance by the licensee or registrant provided that the change is made at the beginning of the year and that no day is omitted or duplicated in consecutive years.</td></tr>
</table>

5 ABBREVIATIONS

Abbreviation	Meaning
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
ALARA	as low as is reasonably achievable
ALI	annual limit of intake
AU	authorized user
bkg	background
CFR	*Code of Federal Regulations*
Ci	curie
cpm	counts per minute
DAC	derived air concentration
DFP	decommissioning funding plan
DIS	decay-in-storage
DDE	
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
ECD	electron capture detector
EDE	Effective Dose Equivalent
FA	financial assurance
GBq	gigabecquerel
GC	gas chromatograph
h	hour
IN	information notice
IP	inspection procedure
kBq	kilobecquerel
L/C	license condition
LLW	low-level radioactive waste
LSC	liquid scintillation counter
MARSAME	Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MBq	megabecquerel
mCi	millicurie
MDA	Minimum detectable activity
MDC	Minimum detectable concentration
mGy	milligray
MR	milliroentgen
mrad	millirads
mrem	millirem
mSv	millisievert
µCi	microcurie
µGy	microgray
µR	microroentgen
NaI	sodium iodide
NCRP	National Council on Radiation Protection and Measurements
NIST	National Institute of Standards and Technology
NMSS	Office of Nuclear Material Safety and Safeguards
NORM	naturally occurring radioactive material
NRC	U.S. Nuclear Regulatory Commission

NSTS	National Source Tracking System
NSTTR	National Source Tracking Transaction Reports
NVLAP	National Voluntary Laboratory Accreditation Program
OAC	Ohio Administrative Code
OMB	Office of Management and Budget
PII	personally identifiable information
P&GD	policy and guidance directive
RIS	Regulatory Issue Summary
RQ	reportable quantities
RSO	radiation safety officer
SI	International System of Units (abbreviated SI from the French Le Systeme Internationale d'Unites)
SSD	Sealed source and device
Std	standard
TEDE	Total effective dose equivalent
TI	Transportation Index
TLD	thermoluminescent dosimeters
UN	United Nations
XRF	X-ray fluorescence analyzer

6 RELATED RESOURCES (REFERENCE DOCUMENTS)

University Policies and Information	
Wright Way Policy 13270	Emergency Care for Injuries & Illnesses
Wright Way Policy 13275	Reporting Injuries & Illnesses
Wright Way Policy 13301	Environmental Health & Safety
Wright Way Policy 13320	Pregnancy in the Workplace & in Academic & Research Settings
Wright Way Policy 13330	Exit Policy for the Closeout/Decommissioning of University Laboratories
External Documentation	
OAC 3701:1	Radiation Control
NUREG-1556	Program-Specific Guidance About Academic, Research and Development, and other Licenses of Limited Scope
49 CFR 172	Hazardous Materials Table
49 CFR 173	Shippers - General Requirements for Shipments and Packaging
University Forms and Systems	
Amendment	
Animal Waste Label	
Annual Review	
Declaration of Pregnancy	
Dose History	
Dosimetry Issuance Card	Dosimetry Issuance Card
Dosimetry Records -- Annual	
Dosimetry Records -- Quarterly	
Exposure Record – Annual (Form 5)	
Individual User Application	
Inventory of Radionuclides card	
Laboratory Hazard Instruction form	Laboratory Hazard Instruction form
License	Ohio Department of Health License for Radioactive Material 03620580021 Amendment 15 Expires 2-1-2022
Liquid Waste Label	
Ohio Department of Health "Notice to Employee" signs	Ohio Department of Health "Notice to Employee" signs
Purchase Order Approval	
Radionuclide Information	List of radionuclides and annual limit information
Radioactive Materials Receipt Form	
Radioactive Spill Report	
RGE Record of Maintenance	
RGE Use Log Template	
RSO-01	Authorized User Form
RSO-02	Faculty User Form (Qualification of Radiation-Generating Equipment User)

RSO-03	Use Authorization Form (Application for Use Authorization)
RSO-03A	Use Authorization Form for Radiation Generating Equipment
RSO-07	Visitor User Application
RSO-10	Inventory of Radionuclides (Yellow Card)
LAR/RSO-14	Animal Care Information Use Authorization

7 ADMINISTRATION OF THE RADIATION SAFETY PROGRAM

7.1 FOREWORD

The Ohio Department of Health (ODH) governs the use of radioactive materials and radiation-generating equipment in Ohio through the **Ohio Administrative Code (OAC)**. Wright State University holds licenses for radioactive materials and registrations for radiation generating equipment, which are issued by the Ohio Department of Health The agency within Ohio Department of Health that handles licensing and registration issues is the Bureau of Environmental Health and Radiation Protection (BEHRP).

The University promotes the philosophy of keeping radiation doses at levels that are As Low As Reasonably Achievable (ALARA) through a comprehensive radiation safety program. The Radiation Safety Program is overseen by the Department of Environmental Health and Safety.

The primary objectives of the Radiation Safety Program are:

a) To implement procedures for compliance with all regulatory requirements by developing, documenting, and implementing the radiation protection program which corresponds with the scope and extent of licensed or registered activities at Wright State University[1];

b) To implement practices that radiation doses to individuals using radioactive materials and radiation-generating equipment are consistent with ALARA through the use of procedures and engineering controls based upon sound radiation protection practices[2],

c) To implement procedures to ensure that radiation doses received by members of the general public from licensed and registered activities are negligible;

d) To maintain control of radiation sources and retains documentation of their disposition; and

e) To review the radiation protection program content and implementation at intervals not to exceed twelve months[3].

This manual establishes the policies and procedures for use of regulated radiation sources. It faithfully complies with the rules promulgated by Ohio Department of Health.

[1] OAC 3701:1-38-11 (D)(1) Radiation protection standards, general provisions.
[2] OAC 3701:1-38-11 (D)(2) Radiation protection standards, general provisions.
[3] OAC 3701:1-38-11 (D)(4) Radiation protection standards, general provisions

Facility Coordinators, Faculty Users and Authorized Users must have access to the Radiation Safety Manual and must keep them accessible to the users under their supervision. The responsibility for safety rests with the user. Each user should read the manual and become familiar with its contents. Applying conditions under Ohio Department of Health rules, following procedures specific to the person's work area, and using common sense form the foundation for individual safety. Should you observe any situation or occurrence that in any way violates the objectives of the Radiation Safety Program or general safety, you must immediately bring it to the attention of your supervisor, Environmental Health and Safety, or the Radiation Safety Officer.

Radioactive materials (RAM) and radiation-generating equipment (RGE) provide versatile tools for research and teaching. Due to possible hazards associated with their use, several levels of responsibility have been established to manage the use and control of radioactive materials and radiation-generating equipment. The following appendices contain information relevant to this manual and radiation source users:

A-I: Definitions and Conversion Factors

A-II: Biological Effects of Ionizing Radiation

A-III: Radionuclide Information

A-IV: Radiation Safety Equations

7.2 COMMITMENTS AND RESPONSIBILITIES

7.2.1 Department of Environmental Health And Safety

The Department of Environmental Health and Safety has the responsibility to:

a) Implements policies and procedures radiation safety, security, and control of radioactive materials and compliance with regulations;

b) Implements procedures to demonstrate radiation safety records and all information provided to the regulatory agencies are complete and accurate;

c) Is knowledgeable about the contents of the license and application

d) Complies with current ODH and U.S. Department of Transportation (DOT) regulations, and the university's operating, emergency, and security procedures, and regulatory license commitments;

e) Provides adequate resources (including space, equipment, personnel, time, and if needed, contractors);

f) Maintains the radiation protection program to ensure that the public and workers are protected from radiation hazards and compliance with regulations;

g) Reports defects, noncompliances, or reportable events in accordance with regulations;

h) Selects and assigns a qualified individual to serve as the radiation safety officer (RSO) for licensed activities and confirmation that the RSO has independent authority to stop unsafe operations and will be given sufficient time to fulfill radiation safety duties and responsibilities; and

i) Implements training procedures to provide radiation workers with adequate training.

7.3 UNIVERSITY RADIATION SAFETY OFFICER

The University Radiation Safety Officer (RSO) is a member of the Department of Environmental Health and Safety and he or she is responsible for the radiation protection program[4]. The Radiation Safety Officer's (RSO's) training and experience should be applicable to and generally consistent with the types and quantities of licensed material listed on the license[5]. The RSO has the independent authority to stop operations that he or she considers unsafe[6].

The RSO's name is listed on the license to ensure that the university always has a responsible, qualified person identified and that the named individual knows of his or her designation as RSO[7]. Appointment of the Radiation Safety Officer requires a license amendment from the Ohio Department of Health (ODH).

7.3.1 Minimum Requirements for the Radiation Safety Officer

The Radiation Safety Officer should have. at a minimum,

a) A college degree at the bachelor's level or equivalent training and experience in physical, chemical, biological sciences, or engineering; and

b) Training and experience commensurate with the scope of proposed activities.

7.3.2 Training and Experience Requirements for the Radiation Safety Officer

The RSO is expected to have the training and experience similar to the types, forms, quantities, and uses of the radioactive material used at the university. The RSO should have obtained training in formal course(s) designed for RSOs, presented by an academic institution, commercial radiation safety consulting company, or a professional organization of radiation protection experts. In addition, the RSO should have experience planning and conducting evaluations, surveys, and measurements similar to those required by the university's program.

7.3.2.1 Training for Radiation Safety Officer

Training should include the following subjects:

a) Radiation protection principles

b) Characteristics of ionizing radiation

c) Units of radiation dose and quantities

d) Radiation detection and measurement instrumentation

e) Biological hazards of exposure to radiation (appropriate to types and forms of byproduct material to be used)

f) Regulatory requirements and standards commensurate with the uses proposed by the applicant

g) Hands-on use of radioactive materials

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[4] NUREG-1556, Vol.7, 8.7.1
[5] NUREG-1556, Vol.7, 8.7.1
[6] NUREG-1556, Vol.7, 8.7.1
[7] NUREG-1556, Vol.7, 8.7.1

7.3.2.2 Experience for Radiation Safety Officer

Experience should include the following areas:

a) Planning and conducting evaluations, surveys, and measurements similar to those that the licensee's radiation safety program requires

b) Use of licensed materials similar in types, forms, and quantities to those proposed for use under the license

c) Security and control of licensed materials

d) Monitoring inventory of materials possessed under the license; maintaining records of

e) Receipts, transfers, and disposal of licensed materials

f) Storage, handling, disposal, and documentation of radioactive waste materials

g) Planning, conducting, and documenting audits and other evaluations of the radiation safety program

h) Evaluation and documentation of radiation exposures

i) Maintaining required records of the radiation safety program and providing required reports

7.3.3 Radiation Safety Officer Responsibilities[8]:

The Radiation Safety Officer implements the policies and procedures for radiation safety, as stated in the Radiation Safety Manual, Ohio Department of Health rules, or directives from regulatory entities.

a) Implements policies and procedures to limit the amount of licensed material that the licensee possesses to the types and quantities of byproduct material listed on the license.

b) Maintains documentation demonstrating that the dose to individual members of the public does not exceed the limit specified in OAC 3701:1-38-13 Dose limits for individual members of the public9.

c) Implements policies and procedures to provide security of radioactive material.

d) Posts documents as required by OAC 3701:1-38-10 Notices, instructions, and reports to workers10.

e) Implements policies and procedures to transport licensed material is transported in accordance with applicable ODH and DOT requirements.

f) Implements policies and procedures to keep radiation exposures are "as low as is reasonably achievable" (ALARA).

g) Oversees all activities involving radioactive material, including monitoring and surveys of all areas in which radioactive material is used.

h) Acts as liaison with regulatory authorities for radiation safety.

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[8] NUREG-1556, Vol.7, Appendix E

[9] OAC 3701:1-38-13 Dose limits for individual members of the public

[10] OAC 3701:1-38-10 Notices, instructions, and reports to workers

i) Provides necessary information on all aspects of radiation protection to personnel at all levels of responsibility, pursuant to OAC 3701 Radiation Control11, and any other applicable regulations.

j) Oversees proper delivery, receipt, and conduct of radiation surveys for all shipments of radioactive material arriving at or leaving from the institution, as well as packaging and labeling all radioactive material leaving the institution.

k) Determines the need for personnel monitoring, distribute and collect personnel radiation monitoring devices, evaluate bioassays, monitor personnel radiation exposure and bioassay records for trends and high exposures, notify individuals and their supervisors of radiation exposures approaching the limits, and recommend appropriate remedial action.

l) Conducts training programs and otherwise instruct personnel in the proper procedures for handling radioactive material before use, at periodic intervals (refresher training), and as required by changes in procedures, equipment, regulations, etc.

m) Supervises and coordinates the radioactive waste disposal program, including effluent monitoring and recordkeeping of waste storage and disposal records.

n) Oversees the storage of radioactive material not in current use, including waste.

o) Performs or arranges for leak tests on all sealed sources and calibration of radiation survey instruments.

p) Maintains an inventory of all radionuclides possessed under the license, and limit the quantity to the amounts that the license authorizes.

q) Immediately terminates any unsafe condition or activity found to be a threat to public health and safety or property.

r) Supervises decontamination and recovery operations.

s) Maintains other records not specifically designated above, for example, records of receipts, transfers, and surveys as required by OAC 3701:1-44-23 Records.10 CFR 30.51, “Records,” and 10 CFR Part 20, Subpart L, “Records.”

t) Holds periodic meetings with, and provide reports to, university management.

u) Implements policies and procedures to train all radioactive materials users.

v) Performs periodic audits of the radiation safety program to ensure that the licensee is complying with all applicable ODH regulations and the terms and conditions of the license (e.g., leak tests; inventories; use limited to trained, approved users); the content and implementation of the radiation safety program to achieve occupational doses and doses to members of the public that are ALARA, in accordance with 10 CFR 20.1101; and required records are maintained.

w) Implements policies and procedures to document the results of audits, identification of deficiencies, and recommendations for change (and maintained for at least 3 years[12]; provide audit materials to management for review; and provide action is taken to correct deficiencies.

[11] OAC 3701:1 Radiation Control

[12] OAC 3701:1-38-20(C) Records.

x) Implement policies and procedures to communicate audit results and corrective actions to all radiation workers, including ancillary personnel.

y) Implement policies and procedures to investigate and report all incidents, accidents, and personnel exposure to radiation in excess of ALARA or 10 CFR Part 20 limits to the NRC and other appropriate authorities, if required, within the required time limits.

z) Maintains understanding of and keep up-to-date copies of ODH regulations, the license, revised licensee procedures, and ensure that the license is amended whenever there are changes in licensed activities, responsible individuals, or information or commitments provided to NRC during the licensing process.

aa) Develops, implements, maintains, and distributes, as appropriate, up-to-date operating, emergency, and security procedures.

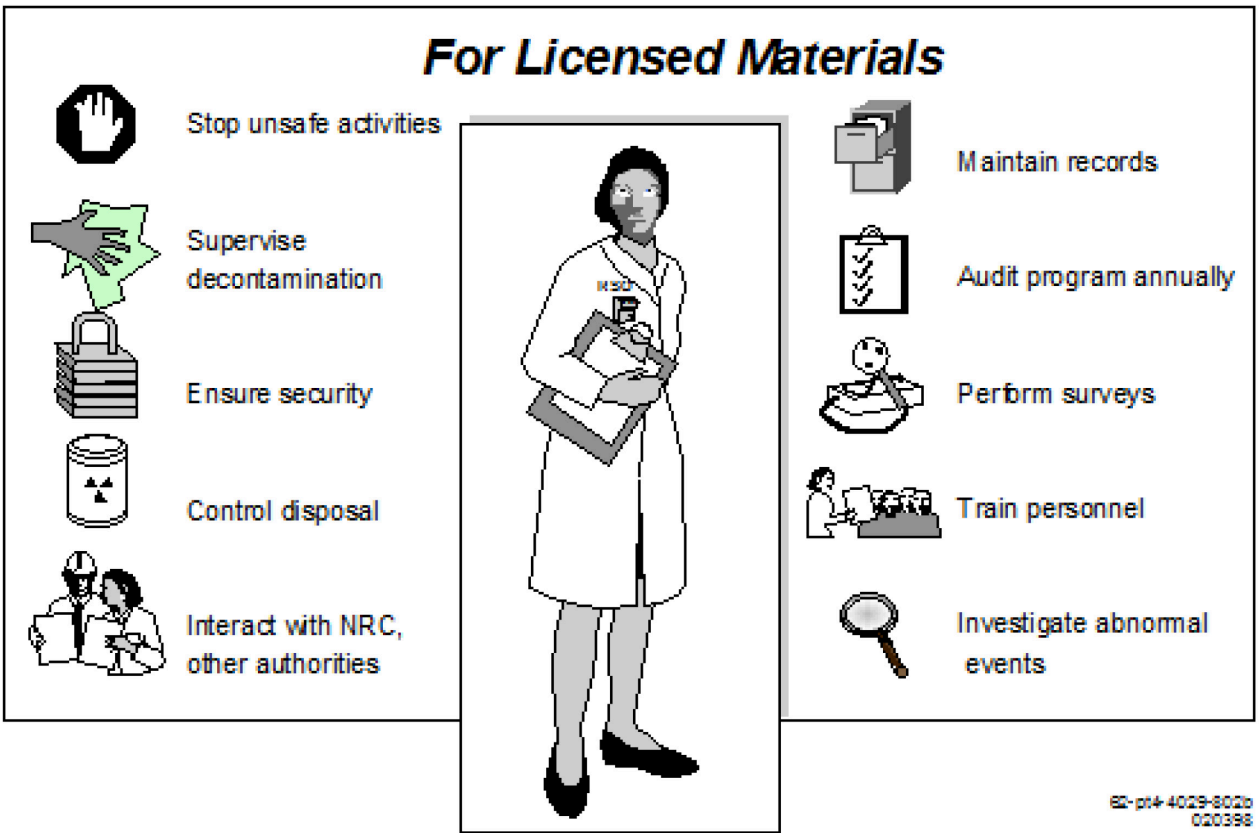

Figure 1. Typical Duties and Responsibilities of the RSO (NUREG-1556, Vol.7).

7.4 REGULATORY COMPLIANCE

The Ohio Department of Health (ODH) periodically inspects the university's Radiation Safety Program to ensure compliance with license requirements and the Ohio Administrative Code (OAC)[13]. The inspectors scrutinize records of the Radiation Safety Officer, Facility Coordinators, Faculty Users, and Authorized Users (AU)[14]. The inspector will audit selected laboratories for compliance with radiation safety standards. The inspection covers such areas as training, procurement, disposal, storage, and general procedures. Severe or numerous violations of license

[13] OAC 3701:1-38-09 Inspection and investigation.

[14] OAC 3701:1-38-09 (A)(1) Inspection and investigation.

requirements and radiation safety policies can result in loss of the license or registration and assessment of administrative or civil penalties. Some examples of violations are unauthorized persons using radioactive materials, possessing unlicensed radioactive materials for which a license is required, or possessing licensed radioactive materials in an unlicensed location.

This manual documents the Radiation Safety Program in accordance with **3701:1-38-11** and the Quality Assurance Program in compliance with **3701:1-66-04** (Radiation-Generating Equipment Requirements and Quality Assurance Standards) and **3701:1-68-02** (Industrial Radiation-Generating Equipment). It includes policies and procedures for the comprehensive implementation of the radioactive materials license and Ohio Department of Health rules. All persons who use radioactive materials or radiation-producing devices must be familiar with the contents of this manual applicable to them and strictly observe its provisions.

The Radiation Safety Officer maintains current copies of the radioactive materials licenses and registrations and Ohio rules. These documents are available from the Department of Environmental Health and Safety, Ohio rules (3701:1-38, 40, 66), and are also available at the Ohio Department of Health web site.

A SAFE ENVIRONMENT DEPENDS ON YOU. Each user of radioactive material or a radiation- generating equipment as well as any member of the university community, is *encouraged* to promptly report any actual or suspected infraction of these policies to a supervisor or the Radiation Safety Officer. Timely action can prevent a minor violation from escalating to a major incident. The Ohio Department of Health **"Notice to Employee"** signs are posted in each use area[15]. These forms contain the Ohio Department of Health phone number to call if you feel university personnel disregard your genuine safety concerns.

Failure to follow safety regulations and the provisions of this manual can jeopardize the authority of the University to use radioactive material and radiation-producing devices and could result in considerable negative impact on teaching and research programs, including possible loss of research funding. Violators of these regulations are therefore subject to penalties such as suspension or withdrawal of user status. In addition, users should be aware that careless or willful violation of Radiation Safety regulations can also subject the perpetrator to civil or criminal prosecution by government agencies.

7.5 ALARA GOALS

ALARA means AS LOW AS REASONABLE ACHEIVABLE.

The Radiation Safety Program uses the *ALARA* philosophy that states that all participants in the program (i.e., committee members, users, and the radiation safety staff) make every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical with consideration for the purpose of the activity, state of technology, economics of improvements, public health and safety, and societal benefits. The underlying basis for ALARA is the linear no-threshold hypothesis, which postulates that any level of radiation exposure carries with it a commensurate risk of adverse effects[16].

To reach ALARA goals, Wright State strives to:

a) Reduce occupational exposure to levels as low as reasonable achievable through good radiation planning and practice.

b) Reduce radiation exposure to the public as low as reasonable achievable.

c) Provide management commitment to encourage good radiation safety planning by establishing and enforcing radiation safety practice, and to remain vigilant to improve the radiation safety program.

[15] OAC 3701:1-38-10 (A)(1)(e) Notices, instructions, and reports to workers.

[16] Regulatory Guide 8.10, Rev. 2 "operating Philosophy for Maintaining Occupational Radiation Exposures as Low as is Reasonably Achievable"

The ALARA principle is practiced throughout the Radiation Safety Program.

7.5.1 ALARA REPORTING

The ALARA program sets personnel dose levels, well below the annual regulatory limits, where an investigation will be initiated to determine the cause of the dose, and dose reduction can be reasonably be done.

7.5.2 ALARA Investigational Levels

The ALARA investigational levels are listed in the ALARA investigational Level tables. The ODH/NRC limits are listed below for comparison. Doses reported by the dosimetry vendor are used to determine if ALARA levels have been exceeded. Different ALARA levels have been established for specific groups. Throughout the calendar year, exposures are routinely evaluated by the Radiation Safety Officer and the Department of Environmental Health and Safety and action to take if the **Investigational Levels** are exceeded.

Exceeding the ALARA investigational values (Table 1) constitutes an occurrence that will be evaluated by the Radiation Safety Officer.

Table 3. ALARA Investigational Levels per Quarter (mrem per Quarter)

Category	Investigational Level (mrem per quarter)	Regulatory Limit (mrem per year)
Adult Worker		
Deep Dose Equivalent (DDE) or Effective Dose Equivalent (EDE)	100	5,000
Total Organ Dose Equivalent	100	50,000
Lens of Eye	500	15,000
Extremities / Skin	500	50,000
Declared Pregnant Woman (Embryo / Fetus)		
Total Effective Dose Equivalent	50	0.5 rem per 9 months
Minor (less than 18 years of age):		
Minor (less than 18 years of age):	50	10% of adult limits

7.5.3 ALARA Investigational Actions

If any of the following unexpected incidents are reported, an investigation of the work practices will be conducted with the purpose of reducing future exposure. The root causes of the exposure will be reviewed with the individual, and methods will be implemented to control future exposures.

ALARA investigation incidents include any of the following:

a) Any personal contamination with radioactivity

b) Any suspected intake of radioactivity.

c) Any radioactive contamination to an unrestricted area.

d) Any radioactive contamination in a restricted area that prevents use of the lab.

7.6 RADIATION DOSE LIMITS

The Ohio Department of Health dose limits are listed below. Exceeding any of these values requires an immediate investigation by the Radiation Safety Officer and notification to Ohio Department of Health.

7.6.1 Occupational Dose Limits

Table 4. Occupational Exposure Limits[17]

Exposure Type	Exposure Limit (rem per year)
Adult Worker	
Deep Dose Equivalent (DDE) or Effective Dose Equivalent (EDE)	5
Total Organ Dose Equivalent	50
Lens of Eye	15
Extremities / Skin	50
Declared Pregnant Woman (Embryo / Fetus)	
Total Effective Dose Equivalent	0.5 rem per 9 months
Minor (less than 18 years of age):	
Total Effective Dose Equivalent	10% of adult limits

7.6.1.1 Adult Worker

The annual occupational dose received by an individual is no greater than any of the following[18]:

a) Total Effective Dose Equivalent. The Total Effective Dose Equivalent (TEDE) limit is 5000 mrem or 5 rem (50 mSv) per year for adult persons using radiation sources[19,20.] The TEDE is the sum of the deep-dose equivalent (DDE) for external exposure and the committed effective dose equivalent (CEDE) for internal exposure.

b) Committed Dose Equivalent. The Committed Dose Equivalent (CDE) limit to any individual organ or tissue must not exceed 50 rem (500 mSv) in any year[21, 22.]

The annual limits to the lens of the eye, to the skin of the whole body, and to the extremities, which are[23]:

a) Skin or Extremity Dose Equivalent. The shallow-dose equivalent (SDE) limit to the skin or extremity is 50 rem (500 mSv) per year[24, 25.]

b) Lens Dose Equivalent. The dose equivalent limit to the lens of the eye is limited to 15 rem (150 mSv) per year[26, 27]

7.6.1.2 Minors

Occupational dose limits for minors shall be ten per cent (10%) of the annual occupational dose limits specified for adult workers[28]

[17] OAC 3701:1-38-12 Occupational dose limits.
[18] OAC 3701:1-38-12 (A)(1) Occupational dose limits.
[19] OAC 3701:1-38-12 (A)(1)(a) Occupational dose limits.
[20] 10 CFR 20.1201 Occupational dose limits for adults
[21] OAC 3701:1-38-12 (A)(1)(b) Occupational dose limits.
[22] 10 CFR 20.1201 Occupational dose limits for adults
[23] OAC 3701:1-38-12 (A)(2) Occupational dose limits.
[24] OAC 3701:1-38-12 (A)(2)(b) Occupational dose limits.
[25] 10 CFR 20.1201 Occupational dose limits for adults
[26] OAC 3701:1-38-12 (A)(2)(a) Occupational dose limits.
[27] 10 CFR 20.1201 Occupational dose limits for adults
[28] OAC 3701:1-38-12 (G) Occupational dose limits.

a) Minors. Minors (*i.e.*, persons under 18 years of age) must receive institutional approval to handle licensed sources. The annual exposure limits for minors are 10 percent of the annual dose for adult workers[29, 30].

7.6.1.3 Declared Pregnant Worker

Dose equivalent to an embryo or fetus shall not exceed five millisievert (0.5 rem) during the entire pregnancy[31].

a) Declared Pregnant Woman. A pregnant woman is subject to the adult exposure limits unless she declares her pregnancy. A "**declared pregnant woman**" voluntarily informs her Authorized User and the Radiation Safety Officer, in writing, of her pregnancy and the estimated date of conception. The declaration will be kept confidential. The dose to the fetus (from both internal and external sources) is then legally limited to 500 mrem equally distributed over the term of the pregnancy (i.e., 50 mrem/month). In the interest of ALARA, the action level for exposure review for declared pregnant women is set at 50 mrem/quarter. Women are not required to declare their pregnancy; however, the lower dose action level only applies to declared pregnant women. The woman may revoke the declaration anytime she chooses. Documented medical proof is not required.

7.6.2 Dose Limits For Members Of The Public

a) Total Effective Dose Equivalent. The Total Effective Dose Equivalent (TEDE) to individual members of the public from licensed or registered radiation sources shall not exceed 100 mrem (1 mSv) per year.

b) Dose Rate. The dose rate in any unrestricted area from external sources shall not exceed 2 mrem/hr (20 μSv/hr).

c) Constraint Dose. Members of the public shall not be exposed (either actually or likely) to airborne radionuclides, excluding radon and its progeny, where their intake could exceed the constraint dose of 10 mrem (0.1 mSv).

7.7 DOSIMETRY ISSUANCE

7.7.1 Dosimeter Types

Dosimeters are worn by persons to monitor their exposure from external sources of ionizing radiation, such as X rays, high-energy β (e.g., ^{32}P) and γ radiation emitters. Personal dosimetry does not effectively monitor doses from low-energy β radiation emitters, such as ^{3}H, ^{14}C, and ^{35}S. The types of dosimetry used at Wright State for monitoring personnel doses are whole body dosimeters, finger rings, pocket dosimeters, and posted dosimeters. All dosimeters, except pocket dosimeters, are exchanged quarterly and processed by an accredited vendor[32].

a) Whole body dosimeters. Whole body dosimeters are worn on the front of the torso between the collar and the waist with the label facing outward. This dosimeter monitors the deep-dose equivalent (DDE), the shallow-dose equivalent (SDE), and the eye (lens) dose equivalent. The university uses optically-stimulated luminescent dosimeters (OSLD) or thermoluminescent dosimeters (TLD) for personal monitoring.

b) Finger rings. A finger ring monitors exposure to the hand (extremity) when handling large quantities of energetic radioactive material such as ^{32}P. They are worn on the hand predominantly exposed to radiation with the label at the palm side of the finger. The finger ring must be worn under the glove to prevent contamination. It uses a small crystal of thermoluminescent (TL) material to measure radiation dose equivalent.

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[29] OAC 3701:1-38-12 (G) Occupational dose limits.

[30] 10 CFR 10.1207 Occupational dose limits for minors

[31] OAC 3701:1-38-12 (H) Occupational dose limits.

[32] OAC 3701:1-38-14 Survey and monitoring requirements.

c) Pocket dosimeters. Self-reading pocket dosimeters are issued from the Radiation Safety Office for short time intervals where exposure to γ or X radiation is likely (e.g., emergency situations). Pocket dosimeters are worn on the body in the same manner as whole body dosimeters. Both types, ionization chambers and solid-state dosimeters, are shock-sensitive. Report immediately to the Radiation Safety Officer if the dosimeter cannot be read, particularly if it is dropped or jarred.

d) Posted dosimetry. Some areas are posted with dosimeters to ensure that exposures to persons around the use area are consistent with ALARA and Ohio Department of Health regulations.

7.7.2 Dosimetry Issuance

Dosimeters are issued when a user will work with sources that emit high-energy β, γ, or X-ray radiation and will likely receive radiation doses as indicated below or at the discretion of the Radiation Safety Officer.

Authorized or Faculty Users can obtain dosimeters for subordinate users by having them complete a Dosimetry Issuance Card from the Department of Environmental Health and Safety. These devices are ordered from an accredited vendor and will be assigned to the appropriate user upon receipt. Users must wear their assigned dosimeter when working with energetic radioactive material. Never wear somebody else's dosimeter.

a) Adult User. When an adult will likely receive a dose of 500 mrem/year (5 mSv/year) deep dose equivalent, 5 rem/year (50 mSv/year) shallow dose equivalent to the skin or extremities, or 1.5 rem/year (15 mSv/year) eye dose equivalent[33].

b) Declared Pregnant Woman. When a declared pregnant woman is likely to receive 50 mrem (0.5 mSv) over the gestational period[34].

c) Minors. When a minor (i.e., person under 18 years of age) is likely to receive one-tenth of the adult user values listed in section (a) above[35].

d) High Radiation Area. Anyone entering a high radiation area (OAC 3701:1-38-15)[36].

"**High radiation area**" means an area, accessible to individuals, in which radiation levels from radiation sources external to the body could result in an individual receiving a dose equivalent in excess of one millisievert (0.1 rem) in one hour at thirty centimeters from the radiation source or thirty centimeters from any surface that the radiation penetrates[37].

7.7.3 Lost or Damaged Dosimeters

Report to the Department of Environmental Health and Safety when a dosimeter is lost and cannot be found. The Radiation Safety Officer will estimate the dose for that dosimetry period. **Inform Environmental Health and Safety anytime you suspect that your dosimeter may have been tampered with or exposed to electrical shock, caustic chemicals, or high temperatures.** The Radiation Safety Officer will track that dosimeter for anomalous readings.

7.7.4 Internal Exposure Monitoring

Internal exposure monitoring is required for a (an):

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[33] OAC 3701:1-38-14 Survey and monitoring requirements

[34] OAC 3701:1-38-14 Survey and monitoring requirements

[35] OAC 3701:1-38-14 Survey and monitoring requirements

[36] OAC 3701:1-38-15 Control of exposure from external sources in high and very high radiation areas

[37] OAC 3701:1-38-01 (79) Definitions

a) Adult when he/she is likely to have an intake in one year in excess of 10% of the applicable ALI for ingestion or inhalation.

b) Minor or Declared Pregnant Women when he/she is likely to have an intake in one year of a committed effective dose equivalent more than 50 mrem (0.5 mSv).

7.7.5 Dosimetry Records and Reports

The Radiation Safety Officer reviews dosimetry results upon receipt for elevated dose levels. Dosimetry records must be retained for the duration of the license.

Any estimated exposures or results from internal monitoring remain part of the record. Any dose exceeding the ALARA action level must be investigated and reported to the Radiation Safety Officer. Reports to Ohio Department of Health concerning dose to an individual will also be provided to the affected person.

7.7.5.1 Annual Dose Reports.

Each year, persons monitored for radiation dose shall be informed of their dose, in writing. The report must be:

a) In writing[38]

b) Include appropriate identifying data, including naming Wright State University, the individual, and the individuals' identification number[39]

c) Include the statement: "This report is furnished to you under the provisions of rule 3701:1-38-10 of the Ohio Administrative Code. You should preserve this report for further reference."[40]

7.7.5.2 Dose History

At the request of an individual, a University representative or the Radiation Safety Officer will send a report of dose during the current year within 30 days of receipt of the request[41].

7.7.5.3 Dose Estimates or Intake Assessments

Situations that require the Radiation Safety Officer to estimate doses or evaluate potential intake of radionuclides will be documented.

8 USE OF RADIOACTIVE MATERIALS

8.1 Ohio Department of Health License for Radioactive Materials

Wright State maintains a license from the Ohio Department of Health for Radioactive Materials. The type of license is approved for use of materials for research and development, gas chromatography, instruction, and for check calibration and reference.

The license names authorized users, type of radioactive materials, limit amounts, and use locations. Any deviation from the license requires an amendment from ODH.

[38] OAC 3701:1-38-10 (C)(1)(a) Notices, instructions, and reports to workers.
[39] OAC 3701:1-38-10 (C)(1)(b) Notices, instructions, and reports to workers.
[40] OAC 3701:1-38-10 (C)(1)(c) Notices, instructions, and reports to workers.
[41] OAC 3701:1-38-10 (C)(3)(b) Notices, instructions, and reports to workers.

8.2 USERS OF RADIOACTIVE MATERIALS (RAM)

Radioactive materials can only be used by permitted users. Users are approved based on their role, training, education, and experience. At Wright State, radioactive materials are classified as:

a) Authorized User

b) Individual User

c) Visitor User

d) Supervised User

e) Non-User

Each User of Radioactive Materials (AU) must submit Form RSO-01 Qualifications of Radioactive Materials User. The User will list their experience using Radioactive Materials by institution, location, isotopes and activities performed, and duration of use[42].

8.2.1 Authorized User (AU)

An Authorized User (AU) is a departmentally affiliated member of Wright State University, including adjunct faculty, who has received permission to act in this capacity after receiving documented approval to use radioactive material independently and supervise subordinate users (i.e., Individual, Visitor, and Supervised Users). The use shall fully comply with research Use Authorizations approved by the Radiation Safety Officer and submitted as an amendment to the Ohio Department of Health. ***No use of radioactive material is permitted until an amendment to the license has been approved by ODH.***

An Authorized User is responsible for the safe use and storage of radioactive materials in his/her laboratory, including usage by anyone under his/her direction and protection of non-users. Additionally, the Authorized User shall ensure that subordinate users have proper training to safely perform each assigned task and respond appropriately to emergency situations. Research Use Authorizations must be submitted to the Radiation Safety Officer for approval before using radioactive materials.

8.2.1.1 Authorized User (AU) Qualifications

An Authorized User (AU) is responsible for the safe use of licensed material in his or her laboratory or area[43]. The AU must have adequate and appropriate training to provide reasonable assurance that they will use the licensed material safely, including maintaining security of, and access to, licensed material, and respond appropriately to events or accidents involving licensed material to prevent the spread of contamination[44]

A prospective Authorized User (AU) must complete Form RSO-01 for approval by the RSO. The applicant shall submit his/her training and experience on Form RSO-01 (Appendix A).

The Authorized User must:

[42] NUREG-1556 Vol. 7
[43] NUREG-1556 Vol. 7
[44] NUREG-1556 Vol. 7

a) Possess at least a bachelor's degree in the physical or biological sciences, or equivalent training and experience in physical, chemical, biological sciences, or engineering[45];

b) Training and experience using radioactive materials. The experience should be using material similar to that proposed for use with regard to the laboratory techniques, possible hazards, and necessary precautions[46]. The training should include the following topics:

c) Radiation protection principles

d) Characteristics of ionizing radiation

e) Units of radiation dose and quantities

f) Radiation detection instrumentation

g) Biological hazards of exposure to radiation (appropriate to the types and forms of byproduct material to be used)

h) Hands-on use of radioactive materials.

i) Wright State's EHS Initial RAM (Radioactive Materials) Training Course fulfils with this requirement.

j) Have access to the Radiation Safety Manual and review the manual, paying close attention to Authorized User responsibilities and other issues relevant to radiation safety.

The Authorized User's experience with radioactive materials should be reasonably current. The Radiation Safety Officer and Ohio Department of Health will judge the adequacy and recentness of experience on a case-by-case basis.

An applicant who is otherwise qualified may gain experience using radioactive material as an Individual User under the supervision of a qualified Authorized User. Upon written recommendation by the supervising Authorized User, the Radiation Safety Officer may upgrade the applicant's status to Authorized User.

8.2.1.2 Authorized User (AU) Responsibilities

The responsibilities of an Authorized User (AU) include the following:

a) Order and possess only the types and quantities of radioactive materials for which the Authorized User has obtained approval. Approval must be documented prior to procurement of materials or proceeding with activities.

b) Ensure that all personnel who enter the Authorized User's laboratory adhere to Use Authorization specifications, the safety rules and regulations recorded in this manual, and any other communications from the University.

c) Instruct subordinate users on safe practices and responsibilities in the lab. The instruction must include relevant sections of the Radiation Safety Manual. Training documented on Laboratory Hazard Instruction Form (or equivalent) is required for persons who are likely to receive a radiation dose of 100 mrem per year or more.

d) Plan and rehearse procedures for radioactive material use to recognize equipment needs, keep radiation exposures As Low As Reasonably Achievable (ALARA), and prepare for unforeseen situations.

[45] NUREG-1556 Vol. 7

[46] NUREG-1556 Vol. 7

e) Keep Use Authorizations current as procedures and users change. Send updated information to the Radiation Safety Officer by memorandum. Review all current Use Authorization(s) for accuracy and any change that may influence radiation safety at least annually.

f) Restrict usage of radioactivity to only those materials and users who have received training commensurate with the proposed usage.

g) Inform the Radiation Safety Officer immediately of radiation related accidents, spills that limit use of the lab or expand into unrestricted areas, personal contamination, or loss of radioactive materials, even if these incidents occur after normal working hours.

h) Ensure subordinate users have appropriate dosimetry devices (OSLDs, finger rings) and check regularly on their use. Also, coordinate with the Radiation Safety Officer to ensure that bioassays are performed when necessary.

i) Maintain proper records of use, transfer, and disposal of radioactive material.

j) Correct and inform the Radiation Safety Officer of any observed deficiencies or potential problems related to radiation safety.

k) Utilize safe measures to minimize radioactive waste. Minimize the storage of radioactive material in laboratories by experimental design and purchase management.

l) Adopt adequate measures for security and control of radioactive material against tampering, loss, theft or unauthorized removal from laboratories or storage areas.

m) Ensure the laboratory use and storage areas and containers are properly labeled.

n) Coordinate the activities of housekeeping and physical plant staff to assure their protection while they are providing services in restricted use and storage areas.

o) Survey for contamination by performing swipes for removable contamination and monitoring with a survey meter at required or appropriate intervals after using unsealed radioactive materials.

p) Decontaminate after spills that occur within areas of responsibility and report such incidents to the Radiation Safety Officer.

q) Ensure Environmental Health and Safety surveys all equipment and lab spaces that may be contaminated before they are released for repair, disposal, or unrestricted use.

r) Arrange for a qualified Authorized User to assume responsibility for ordering materials and general supervision of projects and users during prolonged absences, e.g., sabbatical. Inform the Radiation Safety Officer of plans and arrangements.

s) Keep the Radiation Safety Manual accessible to users.

t) Renew Use Authorizations every five (5) years.

u) Complete the Initial Radioactive Material Training (e.g., Safe Use of Radioactive Materials) initial training, and refresher training, annually.

v) Ensure that all visitors who enter the Authorized User's laboratory are issued the proper personal protective equipment and are instructed to remain a safe distance (isotope specific) from radioactive material use.

w) Notify Environmental Health and Safety prior to leaving the university for retirements or other reasons to prepare for a lab closure.

x) Return dosimetry, if issued, to the Department of Environmental Health and Safety at the termination of the project, employment, or term of the laboratory.

8.2.2 Individual User

An Individual User is a departmentally affiliated member of the university, who uses radioactive materials under the direction of an Authorized User with a limited degree of supervision. The Individual User is responsible for the safe performance of his/her own activities. The Individual User can assist the Authorized User in training new users in the lab. An Authorized User must apply to add a person to his/her Use Authorization as an Individual User. The Radiation Safety Officer grants approval of Individual User status based on education and experience and recommendation from the Authorized User.

8.2.2.1 Individual User Qualifications

8.2.2.1.1 Applicants with Prior Experience

The Authorized User must:

a) Submit the prospective Individual User's training and experience on Form RSO-01 to the Radiation Safety Officer.

b) Ensure the prospective Individual User completes the Safe Use of Radioactive Materials training.

c) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, and user responsibilities. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more.

d) Provide direct (observed) supervision during all use procedures until the Authorized User is confident that the prospective Individual User can work independently. The period of supervision should be commensurate with the person's experience.

e) Add the Individual User to the Authorized User's authorization by memorandum to the Radiation Safety Officer.

8.2.2.1.2 Applicants without Experience.

The Authorized User must:

a) Ensure the prospective Individual User completes the Safe Use of Radioactive Materials training.

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more.

c) Provide direct (observed) supervision during all use procedures until the Authorized User is confident that the prospective Individual User can work independently. The period of supervision should be commensurate with the person's ability.

d) Add the Individual User to the Authorized User's authorization by memorandum to the Radiation Safety Officer.

8.2.2.2 Individual User Responsibilities

a) Use only the types and quantities of radioactive material covered by research Use Authorizations approved by the Radiation Safety Officer.

b) Adhere to the safety rules and regulations recorded in the Radiation Safety Manual and any communications from the Radiation Safety Officer.

c) Practice new techniques and procedures before using radioactivity to keep radiation exposures ALARA and to identify possible problem areas that may hamper safety or research outcome.

d) Inform the Authorized User and Radiation Safety Officer immediately of radiation related accidents, spills, personal contamination, or loss of radioactive materials, even if these incidents occur after normal working hours.

e) Wear issued radiation dosimeters, when appropriate. Keep the dosimeters accessible to the Department of Environmental Health and Safety. Undertake bioassays, as necessary.

f) Inform the Authorized User of observed deficiencies or potential problems related to radiation safety. Inform the Radiation Safety Officer if timely corrective action is not initiated.

g) Maintain adequate measures for security and control of radioactive material against tampering, loss, theft or unauthorized removal from laboratories or storage areas.

h) Survey for contamination at required or appropriate intervals after using unsealed radioactive materials.

i) Assist Authorized User with day-to-day responsibilities, such as keeping complete and accurate records, decontamination of minor spills, labeling use areas and equipment, and keeping other personnel aware of use areas and potential hazards in the lab.

j) Employ general radiation safety precautions.

k) Return dosimetry, if issued, to the Department of Environmental Health and Safety at the termination of the project, employment, or term of the laboratory.

8.2.3 Visitor User

A Visitor User seeks to collaborate with an Authorized User on a project usually less than several months utilizing radioactive materials, but is *not* a member of the university community. The sponsoring Authorized User will submit a Visitor User Application (Form RSO-07) for approval. The visitor will work directly under the Authorized User and cannot supervise any other users in the lab.

8.2.3.1 Visitor User Qualifications

8.2.3.1.1 Applicants with Prior Experience

The Authorized User will be responsible to oversee a visitor user. The Authorized User must:

a) Submit a Visitor User Application form (RSO-07) for the prospective Visitor User. Attach documentation of training and Experience (Form RSO-01) documenting the person's training and experience.

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more.

c) Provide direct (observed) supervision during all use procedures until the Authorized User is confident that the prospective Visitor User can work independently. The period of supervision should be commensurate with the person's experience.

d) Completion of the Safe Use of Radioactive Materials course is encouraged.

8.2.3.1.2 Applicants without Experience

The Authorized User must:

a) Submit the Visitor User Application (form RSO-07).

b) Provide specific training on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent) if the person will likely receive a radiation dose of 100 mrem/year or more.

c) Provide direct (observed) supervision during all use procedures until the Authorized User is confident that the prospective Visitor User can work independently. The period of supervision should be commensurate with the person's background and ability.

d) Completion of the Safe Use of Radioactive Materials course is required.

8.2.3.2 Visitor User Responsibilities

a) Use radioactive materials only as directed by the Authorized User.

b) Employ all general safety precautions.

c) Use only equipment and materials for which specific and instruction and permission has been given.

d) Properly wear dosimeter.

e) Return dosimetry, if issued, to the Department of Environmental Health and Safety at the termination of the project.

8.2.4 Supervised User

A Supervised User is a member of the university who has no previous training or experience using radioactive materials; therefore, the Supervised User must always be directly observed and supervised by an Authorized User or experienced Individual User.

A Supervised User may be a student who uses radioactive material as part of an academic course or laboratory setting or as an interim process to become an Individual User.

8.2.4.1 Supervised User Qualifications

The Authorized User:

a) Will provide specific training before the initial use on laboratory procedures, radiation hazards, rules and regulations, user responsibilities, and emergency procedures. This training must be documented on the Laboratory Hazard Instruction form (or equivalent).

b) Will ensure all use is directly observed and supervised personally or by an Individual User familiar with the project.

c) Must provide the names of Supervised User to the Radiation Safety Officer either individually or by class roster.

8.2.4.2 Supervised User Responsibilities

a) Use radioactive materials only under the direction and observation of the Authorized User.

b) Employ all general safety precautions.

c) Use only equipment or materials for which specific instruction and permission has been given.

d) Return dosimetry, if issued, to the Department of Environmental Health and Safety at the termination of the project.

8.2.5 Non-Users

People who enter radiation use areas, but are not approved to use radioactive materials (*e.g.,* students, maintenance or custodial personnel, Deans, Vice-Presidents, and other members of the general public) must receive instruction in accordance with OAC 3701:1-38-13 if they will likely receive from lab sources a total effective dose equivalent (TEDE) of 100 mrem (1 mSv) in a year[47].

The total effective dose equivalent to individual members of the public who have access to controlled or restricted areas must not exceed one millisievert (0.1 rem) in one year[48].

The radiation safety program includes training for Environmental Health and Safety staff, animal caretakers, custodians, and maintenance workers. Radiation safety awareness is presented to staff in a variety of methods, including New Employee Orientation, Lab Safety Awareness Training, Lab Safety Training, and specific Radiation Safety Training courses. The Laboratory Hazard Instruction form also provides acceptable criteria and documentation to fulfill this requirement.

8.3 RADIOACTIVE MATERIAL USE AUTHORIZATIONS

8.3.1 Use Authorization Applications

A Use Authorization is a written communication between an Authorized User and the Radiation Safety Officer that presents how the radioactive material will be used and describes the safety measures that will be taken.

The Application to Use Radioactive Materials (Form RSO-03) must be reviewed by the Radiation Safety Officer and approved ***prior to purchasing or using*** the materials. Interim approval may be granted by the Radiation Safety Officer for Use Authorization applications that are clearly compliant with this section of the manual. The Radiation Safety Officer will discuss with the Director of the Environmental Health and Safety or any other relevant subject matter expert) any problems or questionable areas regarding approval.

The Use Authorization application must show that anticipated radiation exposures or any release of radioactive material is consistent with ALARA. If animals will be used in the study, see the Animal Use section. Each Use Authorization is terminated on the anniversary date of the fifth year of the approval date. All forms are to typed/printed/signed.

The Radiation Safety Officer will review the Use Authorization (RSO-03), specifically considering the adequacy of facilities and equipment to be used; operating, handling, and emergency procedures; and training and experience of proposed users. The submitted Use Authorization (RSO-03) for use of radioactive materials will address the

[47] 3701-38-13 (B) Dose limits for individual members of the public.

[48] 3701-38-13 (A)(1) Dose limits for individual members of the public.

following topics. Consult with the Radiation Safety Officer if you have questions regarding the Use Authorization application.

a) list all isotopes needed to complete the study, compounds to be used, and the total activity required for each isotope. The compound may be specific (e.g., 32P-[dATP, dCTP]) if the study is limited to those materials; or general (e.g., nucleotides) if the study will use many similar materials. The activity indicated is the most that may be present in the lab at any one time, including that in use, storage, and waste.

b) list the personnel involved, include forms (Form RSO-01) for Individual Users who have previous training and experience and ensure all complete the Safe Use of Radioactive Materials training.

c) list intended use and storage areas.

d) address specific safety issues, such as dosimetry, bioassays, personnel protective measures and equipment, contamination prevention and monitoring, and ventilation requirements.

e) briefly describe the investigation, including procedures and precautions pertinent to use, disposal, and disposition of radioactive materials. Consider the following:

(1) Estimate the activity that will be used each day the experiment is run.

(2) Estimate the activity that will be picked up by Environmental Health and Safety or discharged into the sewer.

(3) Do you plan to use animals? For ^{14}C or ^{3}H, will the activity in animal carcasses exceed 0.05 μCi/gram of animal tissue?

(4) Indicate the brand of scintillation fluid you will use.

(5) Is there a potential for an airborne hazard or contamination of a vacuum system?

(6) Will you generate mixed waste?

8.3.2 Use Authorization Change

a) Minor Changes. Examples of minor changes include adding or deleting an Individual User, changing the possession limit of a radionuclide, or adding an isotope or compound to a Use Authorization that does not involve procedural changes. Minor changes require a memorandum from the Authorized User to the Radiation Safety Officer indicating the change and briefly explaining the reason.

b) Significant Changes. Changes where the procedures or project scope differ significantly from current approved Use Authorizations require the submission an additional Use Authorization application form (Form RSO3). For approval of the Radiation Safety Officer.

c) Use Authorization Renewal. Annually, Authorized Users must review their Use Authorizations to ensure the information is current and accurate. Authorized Users are encouraged to compare their current laboratory procedures, materials used, and personnel against Radiation Safety records.

8.3.3 Use Authorization Suspension

Authorized Users who are not currently using radioactive materials, but may do so in the foreseeable future may place their Use Authorization in suspension by informing the Radiation Safety Officer in writing. Radioactive materials will be removed from the lab and the lab decommissioned and released for unrestricted use pending continued usage.

The Authorized User must notify the Radiation Safety Officer two weeks before radioactive material usage will be resumed.

The Use Authorization will be terminated on the anniversary date of the fifth year of the approval date.

8.3.4 Use Authorization Termination

Authorized Users who plan to discontinue using radioactive materials or end their university affiliation must terminate their appropriate Use Authorizations. The Authorized User must:

a) Inform the Radiation Safety Officer of termination plans,

b) Assure that facilities and equipment are free from contamination,

c) Return all remaining radioactive material and dispose of wastes to Environmental Health and Safety,

d) Return the Radiation Safety Manual, dosimetry, survey meters, radiation protection equipment, and shielding devices to Environmental Health and Safety, and

e) Schedule a final laboratory radiation survey and bioassay where appropriate.

8.4 GENERAL PRECAUTIONS WHEN USING RADIOACTIVE MATERIALS

a) Wear a lab coat, gloves, and safety glasses, as required, while handling unsealed radioactive materials.

b) Monitor the work area and gloves regularly to identify contamination and prevent its spread.

c) Do not eat, drink, or apply cosmetics in areas where radioactive materials are handled. WSU prohibits smoking in all buildings.

d) Keep radioactive work separated from other work, preferably by maintaining areas used solely for radioactivity.

e) Use time, distance, and shielding and contamination control to keep your dose as low as reasonably achievable (ALARA).

f) Work over a spill tray in a certified ventilated enclosure, especially when using large quantities (> 1 mCi) of radioactive materials or compounds that vaporize easily (e.g., 3H-water and 125I-sodium iodide).

g) Use the minimum quantity of radioactivity needed to meet the objectives of the experiment.

h) Never handle unsealed radioactive materials with open cuts or breaks to the skin.

i) Use tongs or other remote handling equipment to minimize exposure to extremities.

j) Never pipette by mouth.

k) Properly wear dosimetry, if issued, for all radioactive work.

l) Wash your hands and, if applicable, monitor yourself before leaving the lab.

m) Document radioactive material usage and waste disposal on inventory cards.

n) Label radioactive containers clearly, indicating nuclide, activity, compound, and date.

o) Dispose of radioactive waste according to provisions of the experimental Use Authorization, never in ordinary trash.

8.5 EXTERNAL EXPOSURE PROTECTIVE MEASURES

8.5.1 Time

Radiation dose can be decreased by reducing the amount of time users spend working with high-energy beta (β) and gamma (γ) emitting radionuclides. Users should practice new procedures *without radioactivity* to become familiar with the steps involved and to identify potential problem areas. Never rush while working with radioactive materials. Hurrying through a procedure can lead to a spill or accident that may actually increase dose.

8.5.2 Distance

Radiation intensity decreases inversely with the square of the distance ($1/d^2$) when the source is small compared to the distance. The dose from low-energy beta emitters (*e.g.*, ^{3}H and ^{14}C) is zero at 10 to 20 cm. For high-energy β and γ emitting radionuclides, remote-handling devices (*e.g.*, tongs or forceps) can reduce radiation dose to hands and fingers when handling containers holding large activities. Practice using tongs without radioactivity to become comfortable working with the tools. Store radioactive materials away from personnel, lab benches, or desks where lab personnel may spend a lot of time.

8.5.3 Shielding

Attenuating material placed in the radiation path can effectively reduce external exposure. The amount of shielding needed is determined by the type and energy of radiation, composition and thickness of shielding material, distance from the source, time spent in the work area, and acceptable level of dose reduction.

The effectiveness of the shielding should be verified using a survey meter.

The exposure rate to an unrestricted area and at the user's position should be reduced to 1 mrem/hr or less for long procedures.

The exposure rate in an unrestricted area must not exceed 2 mrem/hr.

Low-energy beta (β) radiation (*e.g.*, ^{3}H and ^{14}C) has a very short range in material; therefore, additional shielding is not necessary.

Shield high-energy beta emitters (e.g., ^{32}P) with 3/8-inch or more of a low-atomic-number material, such as plastic. Eyewear, such as goggles will substantially reduce ocular exposures and prevent eye contamination. Gamma emitters must be shielded with high-density materials, such as lead.

The Radiation Safety Officer will assist in the design of shielding upon request.

8.5.4 Precautions When Using ^{32}P in Millicurie Amounts

Handling millicurie quantities of ^{32}P when unshielded can expose an investigator to very large dose rates, especially to extremities.

One mCi of ^{32}P in one ml of fluid yields a dose rate of about 2 rem/hour at 15 cm above the mouth of an open vial. This dose rate will increase with increasing activity.

The User should be aware of the potential high dose rates and be vigilant toward employing protective measures and ALARA. The bremsstrahlung dose rates are unimportant compared to the unshielded beta dose rates. At 15 cm from a 40-mCi vial, the dose rate from bremsstrahlung may be 0.004 rem/hour, where the dose rate from beta radiation may be 50 - 100 rem/hour.

Use the following precautions when using ^{32}P in millicurie amounts:

a) Extremity dosimetry and an operational survey meter are required. Place the extremity dosimeter under the glove and on the finger most highly exposed. Double gloves are encouraged.

b) Pipetting must take place behind a 3/8-inch plastic shield to protect the head and torso. Efforts should be made to position the stock vial and final container to minimize travel distance and time. Use a tray to transport petri dishes. Cover the dishes to further reduce personal dose and prevent spillage.

c) An uncollimated liquid-filled pipette tip or petri dish can contribute to dose to the hands. A significant depth of liquid in the petri dish and covers can partially shield the beta dose.

d) For multi-millicurie quantities, the pipette should have a 3/8-inch plastic plate attached to the grip to shield the hand. The shield should be large enough to keep the hand and forearm out of the beam of the stock vial. Once pipetting is done, the used tip should go directly into a shielded waste container.

e) Remove the pipetting hand out from the beam of the stock vial as soon as possible after removing the pipette tip. Remove and replace the stock vial cap using tongs. Replace the cap immediately after pipetting.

f) Monitor your gloves frequently during use. If contamination is found, remove the gloves immediately and dispose of them properly. Adjust your technique to eliminate the cause. Do not accept routine glove contamination. The dose rate from 32P directly on the skin is about 8800 mrem/hour per μCi/cm2. A layer or two of gloves will not decrease that dose rate by much.

g) Monitor your person, including your gloves, face, lab coat sleeves and front, and shoes and the use area for contamination before leaving the work area. Survey for removable contamination as required.

8.6 INTERNAL EXPOSURE PROTECTIVE MEASURES

Radioactive materials are of most concern when they become internally deposited in the body. Radioactive substances can enter the body by inhalation of airborne contamination, oral intake, or absorption through the skin. By working in a well-ventilated space, wearing personal protective clothing, using good work habits, and effectively controlling radioactive materials, internal exposures should not occur.

8.6.1 Personal Protection

Good, basic laboratory technique is the primary defense against contamination and internal exposure. User attire consists of disposable gloves and a lab coat. ANSI-approved safety goggles must be whenever chemical splash hazards or high-energy beta emitters are present.

- Cover open wounds or cuts to avert this route of entry.
- Do not eat, drink, or apply cosmetics in the use area.
- Monitor or change gloves frequently during experiments using unsealed radioisotopes.
- Be sure to wash your hands soon after removing gloves.

When using a high-energy β emitter, monitor gloves, the lab coat, and the use area with a survey meter after the experiment is completed. Surveys of other places (*e.g.*, face, shoes, desk, or phone) may also be necessary if contamination is found.

8.6.2 Protection From Airborne Contaminants

Procedures that can produce contaminated aerosols, dusts, or gases shall be conducted in a fume hood that has been approved by the Environmental Health and Safety Department within the past 12 months. Vials containing tritiated water or large amounts (i.e., greater than 10 μCi) of an unlabeled radioiodine shall be opened in a certified fume hood. When applicable, traps and filters should be incorporated in the experimental setup to ensure that environmental releases are ALARA and prevent contamination of vacuum systems.

Vials containing tritiated water or large amounts (i.e., greater than 10 μCi) of an unlabeled radioiodine shall be opened in a certified fume hood.

Radioactive gases or materials with gaseous radioactive daughters must be stored in gas-tight containers situated in a fume hood or an approved area having adequate ventilation.

8.6.3 Annual Limit on Intake (Ali)

Proper use of protective measures should prevent any personal contamination or internal exposure to radioactive materials. The annual limit on intake (ALI) is the regulatory limit for radioactive material taken into the body by a user in one year. The ALI is based on the intake of a radionuclide (in μCi) that would result in a committed effective dose equivalent (i.e., cumulative exposure) of 5 rem (0.05 Sv) or a committed dose equivalent *(i.e.,* organ or tissue dose) of 50 rem (0.5 Sv). The Radionuclide Information site lists the ALI for several licensed radionuclides.

8.7 WORK AREA PROTECTION

Users must take precautions to prevent their work areas from becoming contaminated or spreading the problem should contamination occur. Work surfaces should be covered with plastic-backed absorbent paper to minimize the potential of contaminating bench surfaces. Material usage should be performed over small sections of absorbent paper or a spill tray (lined with absorbent paper) to contain spills as well as reduce the waste volume. Use and storage areas should be concentrated in a remote part of the lab to reduce the transport of materials. Unsealed radioactive liquids should be transported on a spill tray, or otherwise secured against spillage.

Users shall ensure that vacuum systems remain free of contamination by demonstrating that evacuated gases are not contaminated. Radioactive gases must be passed through a liquid trap (or other effective means) before entering a vacuum pump or the university vacuum system. Separate vacuum pumps should be vented into an exhaust hood when the experiment produces radioactive gases or aerosols. The vacuum pump oil should be periodically checked for contamination.

Good housekeeping can mitigate mishaps. Users should maintain clean, orderly labs to promote a safe environment.

Only "hot" sinks (*i.e.*, sinks designated for radioactivity) shall be used to dispose of liquid waste or wash contaminated laboratory equipment. After usage, sinks should be copiously flushed. Do not fill containers for consumption from a hot-sink tap.

8.8 PURCHASING RADIOACTIVE MATERIALS

8.8.1 Initial Notification for Purchasing Radioactive Material to Radiation Safety Officer

The acquisition of radioactive material requires approval from the responsible Authorized User and the Radiation Safety Officer. The Authorized User must ensure that he/she is permitted to have the material and that possession limits will not be exceeded. Endorsement by the Radiation Safety Officer allows confirmation of the requested material and amount against the Authorized User's approval and prepares for receipt. Approval from the Radiation Safety Officer may be obtained by written authorization, phone, or e-mail.

Purchasing radioactive materials authorizations must include following information:

a) isotope,

b) activity,

c) chemical compound,

d) the words "RADIOACTIVE MATERIAL",

e) the Authorized User's approval, and

f) the approval of a Radiation Safety representative.

8.8.2 Wright Buy

Wright Buy, the University's electronic purchasing system, has a Radioactive Material "Flag" that must be checked when ordering radioactive materials.

8.8.3 Delivery Address

All packages containing radioactive material must be delivered to the Department of Environmental Health and Safety to the attention of the Radiation Safety Officer unless alternative methods for receipt have been approved by the Radiation Safety Officer.

Example delivery address:

Radiation Safety Officer, Department of Environmental Health and Safety, 047 Biological Sciences II.

Users are urged to avoid having deliveries made when the campus administrative officer are normally closed (*i.e.*, evenings, weekends and holidays). Coordination with the Radiation Safety Officer is required if the delivery of a package is expected outside of normal working hours.

8.9 RECEIPT OF RADIOACTIVE MATERIALS

8.9.1 Receipt by Environmental Health and Safety

All packages containing radioactive materials will be delivered unopened, to the Department of Environmental Health and Safety. Trained and qualified personnel from the Department of Environmental Health and Safety will open and inspect the package, perform required surveys [OAC 3701:1-38-18][49], and complete the Radioactive Materials Receipt Form. Following clearance, the material will be added to the University inventory and the package will be delivered to the appropriate user.

Records of receipt must be retained for three years[50].

8.9.2 Package Receipt Procedures

a) Visually inspect the package for any sign of damage or degradation (e.g., wetness not due to precipitation, crushed or severely punctured container).

b) Wear gloves. For high-energy β or γ emitters, also wear dosimetry.

c) If the package is labeled (i.e., White I, Yellow II, or Yellow III) or damage is suspected, the following surveys shall be done within 3 hours of arrival. If the package is received after working hours, the package shall be monitored no later than three hours from the beginning of the next working day[51] (or by 10 a.m. if the package arrives before normal working hours).

[49] OAC 3701:1-38-18 (F) Posting, labeling, and receipt of packages

[50] OAC 3701:1-38-20 (C) Records

[51] OAC 3701:1-38-18 (F)(4) Posting, labeling, and receipt of packages

8.9.2.1.1 Swipe Surveys for Removable Contamination

All packages containing radioactive material except exclusive gaseous and Special Form shipments must be wipe tested on the exterior of the package to check for removable contamination. This includes limited quantity packages. **This must be done before shipment and upon receipt of radioactive material.**

a) Swipe Survey. Monitor (i.e., swipe) the external surfaces of the package for removable contamination. Swipe an average area of 300 cm^2 with a filter pad, or similar absorbent material, using moderate pressure. Count the swipe using a liquid scintillation counter. The amount of radioactivity measured on any single wiping material, divided by the surface area wiped and divided by the efficiency of the wipe procedure (the fraction of non-fixed contamination transferred from the surface to the absorbent material), may not exceed the limits listed in (Table 3) at any time during transport. The actual wipe efficiency may be used, or the wipe efficiency may be assumed to be 0.10.

   (1) For γ emitting radionuclides, swipes can be counted on a gamma-well counter.

b) Action Level: Swipe survey is 200 dpm/100 cm^2 or greater

   The Legal Limits are found in 49CFR173.443 403 Table 9 (as published in the January 1, 2014 Code of Federal Regulations)[52]. (Table 3):

   (1) 22 dpm/cm^2 (6600 dpm/300 cm^2) for β-γ emitters and low toxicity α emitters, such as natural thorium or uranium, ^{238}U, or ^{232}Th.

   (2) 2.2 dpm/cm^2 (660 dpm/300 cm^2) for other α emitters.

c) If the wipe test indicates no radioactive contamination is present on the exterior of the package (e.g., less than 22 dpm/cm^2), process the package as usual

d) If the wipe test results indicate that removable contamination levels are >22 dpm/cm^2 and <220 dpm/cm^2, the package should be decontaminated prior to further handling. Notify RSO.

e) If wipe test results indicate that removable contamination levels exceed 220 dpm/cm^2, RSO shall be notified immediately.

8.9.2.2 External Radiation Levels

a) External Radiation Levels. Monitor the surface of the package and at one meter with a radiation detector. Record readings in mrem/hr (or mSv/hr).

b) Action Levels. The surface dose rate for such packages shall not exceed 200 mrem/hour.

Legal Limits[53] are found in 49CFR172.403 Table 9 (as published in the January 1, 2014 Code of Federal Regulations)[54]. (Table 4)

   (1) White I: <0.5 mrem/hr on the package surface.

   (2) Yellow II: $\leq$50 mrem/hr on the surface AND $\leq$1 mrem/hr at one meter.

   (3) Yellow III: $\leq$200 mrem/hr on the surface AND > 1mrem/hr at one meter.

c) Ensure that the container label and shipping manifest agree with purchase order.

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[52] OAC 3701:1-50-17 (I) Routine determinations

[53] 49 CFR 172.403 Class 7 (radioactive) material

[54] OAC 3701:1-50-17 (I) Routine determinations

Table 5. Radioactive contamination action levels[55]

Radioactive Contamination	Bq/Cm^2	μCi/cm^2	dpm/cm^2
Beta and gamma emitters and low toxicity alpha emitters	0.4	10^{-5}	22
All other alpha emitting radionuclides	0.04	10^{-6}	2.2

Note 1. 49CFR173.443 Table 9 was revised in 2015 to change the contamination limits in dpm/cm2 from 220 to 240 for beta and gamma and low toxicity alpha emitters, and from 22 to 24 for all other alpha emitters. The 2015 revision provided the correct conversions from the 4 and 0.4 Bq/cm^2 values.

8.9.2.3 Packaging Material Surveys

e) Survey the packaging material (e.g., the cardboard box and Styrofoam insert). If negative for contamination, remove or obliterate all markings indicating radioactivity and dispose as normal trash. Once you receive the package, be sure to survey the empty package prior to disposal and remove or deface any information related to radioactive content. You must use the check off box on your receipt form to document that this has been performed. Styrofoam containers for some companies may be shipped back to the manufacturer if not contaminated.

Do not dispose of dry ice down the drain. Allow the ice to melt prior to drain disposal.

f) Notify the Radiation Safety Officer immediately if:

(1) the package appears damaged; the security seal on the outer package is broken;

(2) a labeled package is delivered to the wrong place;

(3) the package contents do not agree with the packing slip; or

(4) the swipe survey or external radiation levels exceed action levels.

g) If any of the removable contamination limits are exceeded upon receipt, stop and immediately notify the RAO, the final delivery carrier, and ODH by telephone at 614-644-2727.

[55] OAC 3701:1-50-01(H) Definitions

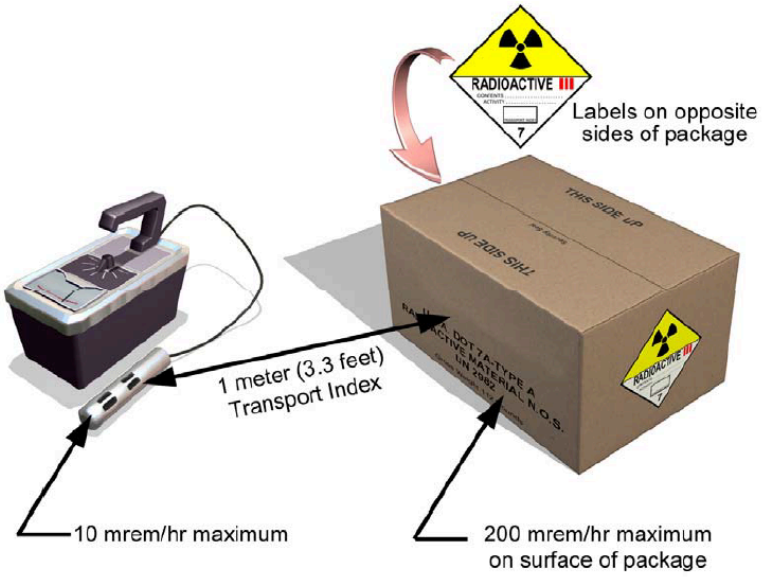


Figure 2. Package Radiation Limits (Source: Radioactive Material Regulations Review, Pipeline and Hazardous Materials Safety Administration, 2008)

Table 6. Radioactive Material Labels, Description, Maximum Radiation Surface Levels, and Transport Indices.

Label			
Label Description	White-I	Yellow-II	Yellow-III
Maximum Radiation Surface Level (RSL), mrem/h	RSL < 0.5	0.5 < RSL < 50	50 < RSL < 200
Transport Index (TI) at one meter	Background	< 1 mrem/h	1-10 mrem/h

8.10 LOCATIONS OF USE AND STORAGE

8.10.1 Licensed Locations

The university's license with Ohio Department of Health applies to all licensed radioactive materials in places specifically listed on the license. Possession of licensed radioactive material at any other location constitutes a violation of the Ohio Department of Health license.

8.10.2 Approved Use Locations

Radioactive material shall be used or stored only in areas specified in the Authorized User's Use Authorization application (Form RSO-03), as approved by the Radiation Safety Officer. The laboratory must be properly equipped for the proposed use, such that assurances for supervision, safety, and security are present. Suitable provisions shall be made to prevent inadvertent exposures to students, staff or the public; releases of radioactive material; and loss, unauthorized removal, or theft of materials. All transfers or shipments of radioactive material must comply with the university transportation policies.

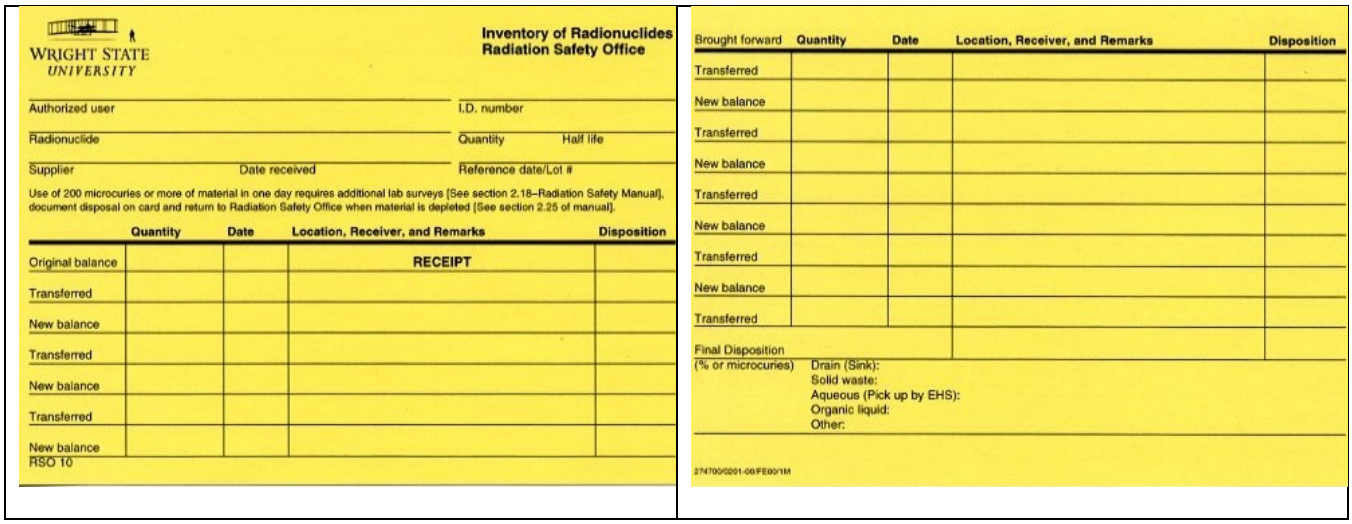
Research laboratories should consolidate use or storage areas for radioactive material to minimize the movement of materials through the lab. Use areas should be reasonably isolated from other projects not using radioactive material and clearly marked with "Caution - Radioactive Material" tape.

The Radiation Safety Officer maintains a list of current and former use locations as required by Ohio Department of Health for decommissioning. This list is updated at least every two years.

8.11 INVENTORY OF RADIOACTIVE MATERIALS

8.11.1 Inventory Cards

The Radiation Safety Officer initiates and distributes yellow *Inventory of Radionuclides* cards (Form RSO-10) with each unsealed source of radioactive material received. Continued maintenance of these cards with current information on use and disposal is necessary for keeping the university's inventory current and accurate. When all the material is disposed, the user indicates the distribution of the waste and returns the card to Environmental Health and Safety.



WRIGHT STATE UNIVERSITY

Inventory of Radionuclides
Radiation Safety Office

Authorized user | I.D. number

Radionuclide | Quantity | Half life

Supplier | Date received | Reference date/Lot #

Use of 200 microcuries or more of material in one day requires additional lab surveys [See section 2.18–Radiation Safety Manual], document disposal on card and return to Radiation Safety Office when material is depleted [See section 2.25 of manual].

	Quantity	Date	Location, Receiver, and Remarks	Disposition
Original balance			RECEIPT	
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				

RSO 10

Brought forward	Quantity	Date	Location, Receiver, and Remarks	Disposition
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				
Transferred				
Final Disposition (% or microcuries)	Drain (Sink): Solid waste: Aqueous (Pick up by EHS): Organic liquid: Other:			

274700/0201-00/FE00/1M

Figure 3. Inventory Card, Form RSO-10 (Left, Front; Right, Back)

8.11.2 Central Inventory

Environmental Health and Safety maintains an inventory of radioactive materials. Semi-annually the Department of Environmental Health and Safety performs an inventory of all radioactive materials to ensure the central inventory is up-to-date and that all sealed sources are accounted.

Records of inventory will be maintained for a period of three (3) years from the date of each inventory, and will include the radionuclides, quantities, manufacturer's name and model numbers, and the date of the inventory[56].

8.11.3 Inter-Laboratory Transfer of Radioactive Materials

The transfer of radioactive materials to another Authorized User requires that the recipient be authorized by the Radiation Safety Officer to possess the type and quantity of material being provided. The Radiation Safety Officer must be informed so that the inventory can be updated with the new location and owner. The transfer may involve consigning all (full consignment) or part (partial consignment) of stock materials. The below procedures are guidelines that fulfill the requirement of being able to track the material. Other means may be applied providing that Authorized Users only possess materials for which they are approved, the central inventory is updated, and the new user has a way to document his/her usage and disposal.

When transporting radionuclides between labs, users will take precautions to protect unrestricted areas against contamination. Unsealed materials must be contained in a labeled, leak-proof receptacle (*e.g.*, a sealed plastic bag) that would not likely break if accidentally dropped.

Radioactive material to be transferred must be packaged to minimize external dose rates and to ensure that the material is well contained, including double containment for liquids. Ensure that it is free from external contamination (200 dpm/100 cm^2). If you plan to walk the material, consider using a cart to push the RAM in rather than carrying it depending on the dose rates of the package. This is a good ALARA practice.

8.11.3.1 Procedures for Full Consignment of a Radioisotope:

a) Ensure the recipient is approved to possess the material.

b) On the *Inventory of Radionuclides* card issued for that material:

   (1) Mark a single line through the name of the current "Authorized User" and write the name of the new receiving Authorized User.

   (2) On the next available "New balance" line, write the "Quantity" (activity) transferred, "Date" of transfer, and "Remarks" indicating the transfer (*e.g.*, Transferred to Dr. X in BS II Room 459).

   (3) Give the material and revised card to the recipient Authorized User.

c) Inform the Radiation Safety Officer of the transfer by written documentation. Send the Radiation Safety Officer a photocopy of the revised card. The Radiation Safety Officer will update the central inventory with the new responsible user and location.

8.11.3.2 Procedures for Partial Consignment of a Radioisotope:

a) Ensure the recipient is approved to possess the material.

b) On the next available "Transferred" line on the *Inventory of Radionuclides* card, write the "Quantity" (activity) transferred, "Date" of transfer, and "Remarks" indicating the transfer (e.g., Transferred to Dr. X, 459 BS II).

c) Make two copies of the card. Line out the former responsible user and add the name of new Authorized User to both copies.

d) On the original card, enter the activity remaining on the next "New balance" line.

e) Provide one copy of the card to the new Authorized User and one to the Radiation Safety Officer.

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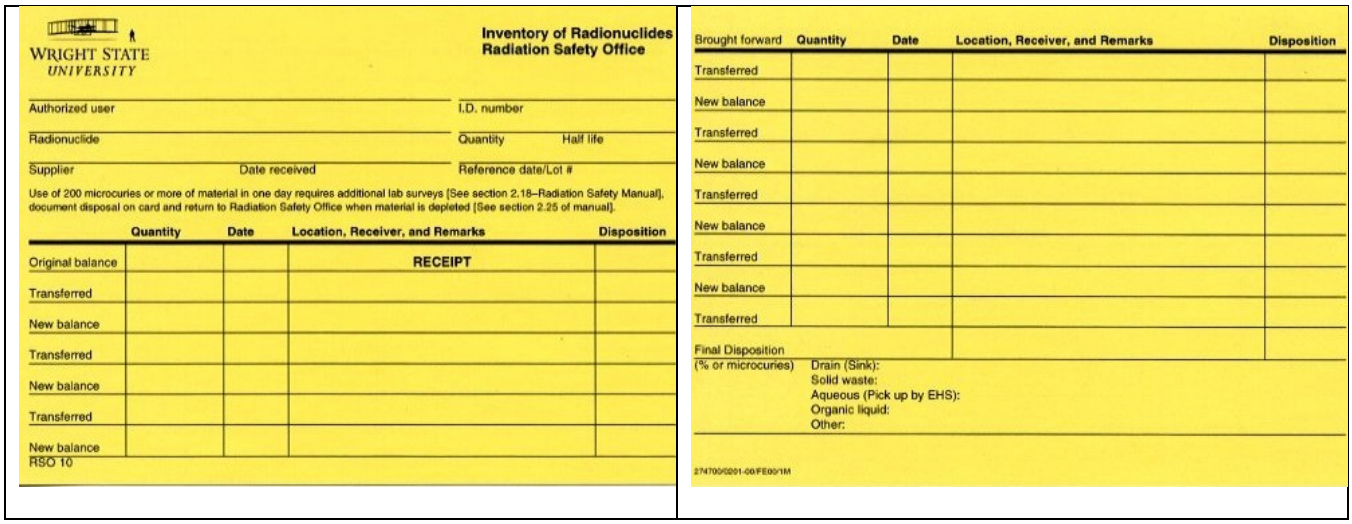
[56] NUREG 1556 Volume 7, Rev.1, Record Maintenance, 2017.

f) The Radiation Safety Officer will update the central inventory.



WRIGHT STATE UNIVERSITY

Inventory of Radionuclides
Radiation Safety Office

Authorized user | I.D. number

Radionuclide | Quantity | Half life

Supplier | Date received | Reference date/Lot #

Use of 200 microcuries or more of material in one day requires additional lab surveys [See section 2.18–Radiation Safety Manual], document disposal on card and return to Radiation Safety Office when material is depleted [See section 2.25 of manual].

	Quantity	Date	Location, Receiver, and Remarks	Disposition
Original balance			RECEIPT	
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				

RSO 10

Brought forward	Quantity	Date	Location, Receiver, and Remarks	Disposition
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				
Transferred				
Final Disposition (% or microcuries)			Drain (Sink): Solid waste: Aqueous (Pick up by EHS): Organic liquid: Other:	

274700/0201-00/FE00/1M

Figure 4. Example of Inventory Card to indicate transfer of Radioactive Material.

8.12 Transport (Shipment) of Radioactive Material

Packages of radioactive material shipped over public roads must comply with regulations of the Department of Transportation (49 CFR 172, 173) and Ohio Department of Health rules. These regulations specify numerous requirements, such as: package labeling, manifests, contamination surveys, exposure rate measurements, and hazardous materials training. To ensure compliance with these requirements, ***only the Radiation Safety Officer or trained and qualified Environmental Health and Safety personnel can authorize the shipment of radioactive materials over public roadways.***

When radioactive materials are to be shipped from the university, trained and qualified Environmental Health and Safety staff will inspect the contents and packing, check for contamination and radiation levels, and ensure all other regulatory requirements are met.

The Authorized User must provide the complete name and address of the intended recipient including the delivery address for the receiving department. A copy of the recipient's NRC or agreement state license ***must be*** obtained ***prior*** to shipping to ensure recipient can possess the material.

Transport by private conveyance is prohibited, unless approved by the Radiation Safety Officer.

All radioactive material must have documented approval prior to transport.

8.13 Security

The loss or theft of radioactive material can result in a violation of the Ohio Department of Health license and possibly personal injury or environmental contamination.

Licensed radioactive materials in storage or use must be secured against tampering, loss, unauthorized removal and theft.

The room where materials are used or stored must be locked whenever a user is not present.

Radioactive materials secured in a locked container (*e.g.*, freezer) achieve this requirement when the above measures cannot be met.

The University or the Department of Environmental Health and Safety may require additional security measures or allow alternate security methods, depending on the specific situation.

Lab personnel should assist unfamiliar persons who enter the lab and ensure they do not enter an area where they would likely receive a dose of 100 mrem in a year without radiation safety training. Food and beverages must not be stored with licensed radioactive material.

Immediately inform the Radiation Safety Officer if radioactive material is discovered missing.

8.14 Posting / Labeling Warning Signs

Warning signs and labels heighten the awareness of persons who may enter the lab. Labels mark areas and equipment that may be contaminated and provide a constant reminder for laboratory personnel, custodians, and maintenance personnel to exercise caution and responsible action. The Authorized User ensures that labels on equipment, benches, and containers are appropriate. The Radiation Safety Officer evaluates posting and labeling when auditing laboratory practices.

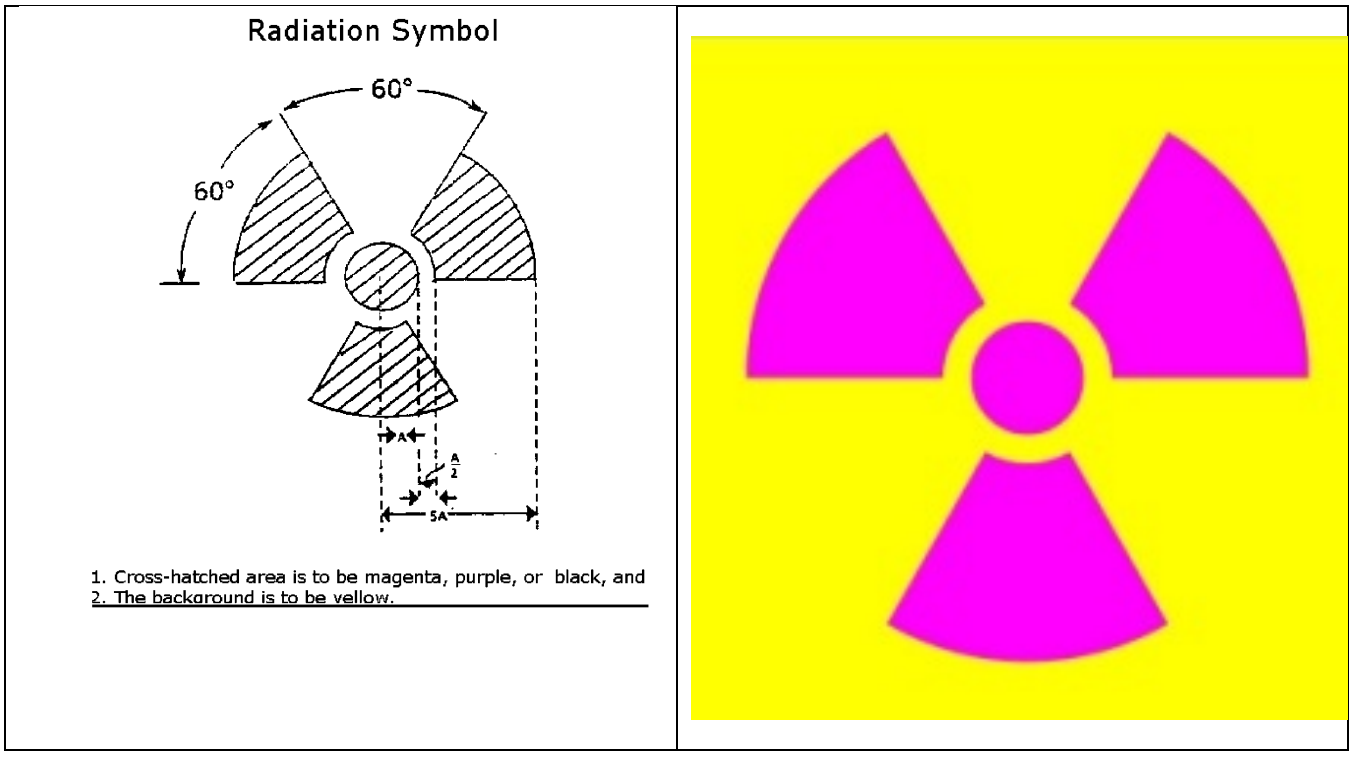


Figure 5. (Left) Radiation Symbol Requirement[57]., (Right) Example of Radiation Symbol

[57] OAC 3701:1-38-18 (A)(4)(e) Posting, labeling, and receipt of packages.

8.14.1 Posting At Radiation Use Areas

a) Radioactive Materials (RAM). A warning sign bearing the radiation symbol and "Caution Radioactive Material" must be conspicuously posted in or at the entryways to labs and store rooms in which radioactive materials are being used or stored in amounts exceeding ten times the quantity of material specified in OAC 3701:1-38 Appendix A[58] , which are the values listed on the Radionuclide Information form (*Required Area Posting*) [OAC 3701:1-38-18][59]. The name of the individual responsible for the posted area should be displayed at each entryway to facilitate contact in case of emergency. Postings must not be removed from any room, except by Radiation Safety personnel following a clearance survey.

Table 7. Posting requirements for Radionuclides[60]

Radionuclide (In Atomic Number Order)	Quantity (µCi)	Quantity (mCi)
Hydrogen-3	1,000	1
Carbon-14	100	0.1
Phosphorus-32	10	0.01
Phosphorus-33	100	0.1
Sulfur-35	100	0.1
Nickel-63	100	0.1
Iodine-125	1	0.001
Iodine-129	1	0.001
Cesium-137	10	0.01
Barium-133	100	0.1
Polonium-210	0.1	0.0001
Radium-226	0.1	0.0001

b) Radiation Area. A warning sign bearing the radiation symbol and "Caution Radiation Area" must be conspicuously posted in or at the entryways to labs and storerooms in which a radiation area is present. A radiation area is an accessible area where the dose rate at 30-cm from the source or shielding exceeds 5 mrem/hr[61].

[58] OAC 3701:1-38-18 (A)(4)(e) Posting, labeling, and receipt of packages.
[59] OAC 3701:1-38-18 (A)(4)(a) Posting, labeling, and receipt of packages.
[60] OAC 3701:1-38-18 Appendix Quantities of Licensed Material Requiring Labeling.
[61] OAC 3701:1-38-18 (A)(3) Posting, labeling, and receipt of packages.

Figure 6. Example of Caution Radiation Area Sign.

c) Notice to Employees. Ohio Department of Health form 4786.32, "*Notice to Employees*", must be visibly posted in or near laboratories where the radioactive materials are located [OAC 3701:1-38-10][62]. Each notice has been amended to include a statement indicating that users may review Ohio Department of Health rules, current licensing documents, or applicable operating procedures by contacting the Radiation Safety Officer.

d) Damaged Signs. The Authorized User will notify the Radiation Safety Officer for replacement if any posted form is found to be defaced, altered, or removed.

e) Sign Removal. Only a representative of the Radiation Safety Office, following a release survey, may remove a posted radiation sign.

f) Exemptions to Area Posting.

(1) An area or room that contains a source of radiation need not be posted with a caution sign provided that the source is located in the area or room for a period of less than eight hours, and the source of radiation is continuously attended to during these periods by an individual who takes the precautions necessary to prevent the exposure of individuals to sources of radiation in excess of the limits in OAC 3701:-38-13, and the area or room is subject to other licensee or registrant control[63].

(2) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level at thirty centimeters from the surface of the sealed source container or housing does not exceed 0.05 millisievert (0.005 rem) per hour[64].

[62] OAC 3701:1-38-18 (A)(3) Posting, labeling, and receipt of packages.
[63] OAC 3701:1-38-18 (B)(1) Posting, labeling, and receipt of packages.
[64] OAC 3701:1-38-18 (B)(3) Posting, labeling, and receipt of packages.

8.14.2 Use Areas Within Laboratories and Equipment Labels

a) Use Areas. The borders of use areas (*e.g.*, benches, hot sinks, fume hoods) within the lab shall be conspicuously marked with “Caution-Radioactive Material" labels. Areas with residual contamination must also be marked and covered to prevent the spread of contamination. Laboratory personnel must survey for contamination when a use area is discontinued or moved to another location within a restricted laboratory. The survey documentation must be retained for 3 years[65].

b) Radiation Areas. Radiation areas in the laboratory*, i.e.,* areas where radiation levels are sufficient to expose a continuously present individual to 5 millirem in any hour shall be labeled as a radiation area.

c) Equipment. Equipment or appliances (*e.g.,* refrigerators, centrifuges, pipettes) used with or contaminated with radioactive material shall bear a label with the radiation symbol and "Caution-Radioactive Material". Labeled equipment must be surveyed for contamination prior to disposal, repair, or unrestricted use. The Radiation Safety Office will perform this survey when requested by laboratory personnel.

Figure 7. Radioactive Material Label.

8.14.3 Container Labels

a) Containers in which materials are held shall bear a durable, clearly visible label bearing the radiation caution symbol and the words "Caution Radioactive Material." The container label shall also indicate sufficient information, such as the following, so that persons working in the area can take precautions to minimize exposures. The information must include: isotope, compound, activity, radiation levels, and date of assay or receipt[66].

Figure 8. Example of Radioactive Material Container Label

[65] OAC 3701:1-38-20(C) Records.

[66] OAC 3701:1-38-18 (C)(1) Posting, labeling, and receipt of packages.

b) Removing Container Labels. Containers must be surveyed prior to release. All radioactive material markings must be removed or defaced from uncontaminated, empty containers before disposal or release for unrestricted use[67].

c) Exemptions to Containers Labeling.

(1) Containers holding material in amounts less than indicated on the Radionuclide Information form, Container Labeling[68].

(2) Containers attended by an individual who takes precautions to prevent exposure to others (e.g., beakers, flasks, and test tubes that are used transiently in laboratory procedures and subsequently cleaned in a hot sink)[69].

(3) Containers when they are in transport and packaged and labeled in accordance with the regulations of the United States Department of Transportation[70]

8.14.4 Sign / Label Acquisition

Radiation posting or warning signs are available from the Department of Environmental Health and Safety. Labeling tape may be obtained from Environmental Health and Safety, Laboratory Stores or commercial vendors.

8.15 SURVEYS FOR CONTAMINATION

Surveys for radioactive contamination are necessary to demonstrate either that no contamination is present or to identify contaminated surfaces so that they may be cleaned before contamination spreads. Users shall perform sufficient surveys to identify any contamination resulting from their usage. The Radionuclide Information form shows recommended methods of laboratory monitoring for commonly used isotopes. Two methods of contamination monitoring are surveying for removable contamination (also called swipes or wipes) and using an operational survey meter for monitoring accessible surfaces.

8.15.1 Surveys for Removable Contamination (Swipes)

a) Swipe Frequency. Use and adjacent work areas must be surveyed for removable contamination (Table 6):

(1) **Monthly**, if the activity used in a day is **200 μCi or less**. Environmental Health and Safety routinely performs these surveys.

(2) **Weekly**, if the activity used in a day is **more than 200 μCi**. These surveys must be pd within one week after the high usage. The user is responsible for ensuring these surveys are completed. Environmental Health and Safety will perform this survey on request.

(3) **By the end of the day**, if **1 mCi or more** of ^{125}I is used (see Iodinations). When using more than 1 mCi of other beta or gamma emitters, users are encouraged to perform swipe surveys immediately following usage. Environmental Health and Safety will perform these surveys on request. After use of ^{32}P (or other high energy beta or gamma unsealed sources), a complete survey of the user and the work area with an operational survey meter must be performed.

(4) **Immediately**, if contamination is suspected.

Table 8. Survey swipe frequency and radioactivity criteria for laboratory personnel.

Swipe Frequency	Radioactivity Criteria	Responsibility Requirement
Monthly	Less than 200 μCi	Environmental Health and Safety

[67] OAC 3701:1-38-18 (C)(2) Posting, labeling, and receipt of packages.
[68] OAC 3701:1-38-18 (E)(1-2) Posting, labeling, and receipt of packages.
[69] OAC 3701:1-38-18 (E)(3) Posting, labeling, and receipt of packages.
[70] OAC 3701:1-38-18 (E)(4) Posting, labeling, and receipt of packages.

Weekly	More than 200 μCi	Lab personnel or EHS by request
By the end of the day	More than 1 mCi of I-125 or	Lab personnel
Immediately following usage	• More than 1 mCi of other beta or gamma emitters • After use of ^{32}P (or other high energy beta or gamma unsealed sources)	Lab personnel
Immediately	If contamination is suspected	Lab personnel Must contact RSO

8.15.2 Recommended Swipe Procedures.

a) Put on a plastic glove on the swiping hand. This requirement may be waived in non-use areas where contamination is not expected.

b) Use a wet or dry swipe pad (filter paper is acceptable). Wet pads collect contamination more efficiently, but are harder to work with than dry pads.

c) Applying moderate pressure, press the pad on the surface to be monitored. The area surveyed should cover 100 cm^2 (≈ 4" x 4"). If no contamination is expected, the survey area can be expanded.

8.15.2.1 Liquid Scintillation Counting (for α, β, and low-energy γ emitters).

a) Place the swipe pads in individual scintillation vials and add scintillation cocktail.

b) In one vial add a blank pad, which represents the background level.

c) Count the vials using a program that includes the energy of the isotope used.

8.15.2.2 Gamma Well Counting (for γ emitters only)

a) Place the swipe pads in individual counting tubes. In one tube add a blank pad, which represents the background level.

b) In another tube, add a reference source (e.g., ^{125}I-Sim, ^{137}Cs - depending on the energy of the suspected contaminant).

c) Count the tubes using a program that includes the energy of the reference source and the isotope used.

8.15.3 Swipe Result Documentation.

a) The print out from the counter may be used as documentation for the survey or the survey data may be transcribed to another sheet. The record must contain the following information and be retained for 3 years[71] for review by inspecting personnel. A diagram of the lab is helpful to correlate the survey results to physical locations in the lab. The record should include the:

(1) date

(2) room number,

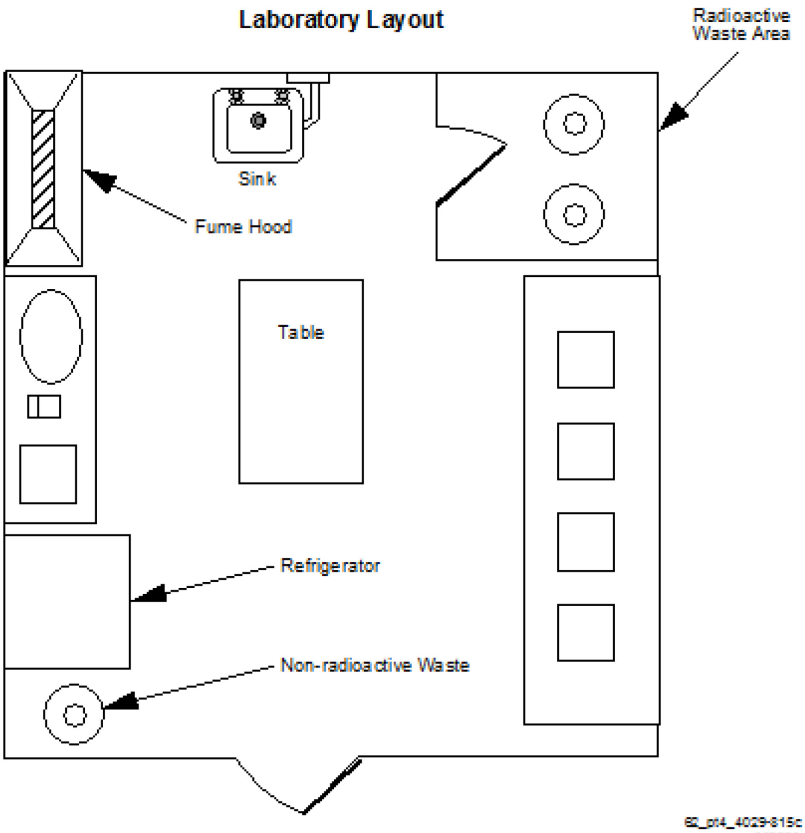
[71] OAC 3701:1-38-20(C) Records.

(3) make and model of the instrument used to count the swipes,

(4) cpm (and dpm, if the efficiency or quench curve is established),

(5) a means of tracking the swipe results to specific locations in the lab (i.e., descriptively (e.g., floor near fume hood) or diagrammatically (e.g., correlate the value to a diagram of the lab)), and

(6) signature or initials of the person performing the survey.



b)

Figure 9. Example of laboratory layout (Source: NUREG 1556, Figure M-1, 2017)

8.15.4 Swipe Action Levels.

8.15.4.1 Restricted Areas.

a) Work areas and equipment should be kept as free of contamination as practical.

b) The action level for decontamination of β or γ emitters is 200 dpm per 100 cm² or three times background.

c) The action level for decontamination of α emitters is 20 dpm per 100 cm².

Table 9. Action levels for restricted areas.

Type of radioactivity	Action Level
β or γ emitters	200 dpm per 100 cm² or three times background
α emitters	20 dpm per 100 cm²

8.15.4.2 Unrestricted Areas.

a) In unrestricted areas or areas that are to be released for unrestricted use, no contamination should be evident. This condition is met if the measured values cannot be distinguished from background level (i.e., are less than the minimum detectable level (MDL) for the detecting system).The following equation may be used for determining the MDL, where R_b is the background count rate (cpm) and t_s is the sample counting time (minutes, providing the counting times for the background and sample are the same).

$$MDL = \frac{3 + 3.29\sqrt{2R_b t_s}}{t_s} \quad (2)$$

b) An acceptable level exists when the sample count rate minus the background count rate is less than the MDL.

c) The Radiation Safety Officer will evaluate values that exceed the MDL on a case-by-case basis.

8.15.5 SURVEY METER MONITORING

a) Laboratories that use over 200 μCi of high-energy β or γ emitters must be equipped with a portable survey meter for personnel and area monitoring.

b) Gloves and the use area should be monitored frequently during operations using radioactivity. After the procedure is completed, the user should monitor all potentially contaminated surfaces (e.g., the use area, gloves, lab coat, shoes, adjacent areas). This survey is required when using 1 mCi or more of high-energy beta or gamma emitters. If the survey is negative, the gloves should be disposed and hands washed prior to leaving the laboratory.

8.15.5.1 Meter Appropriation

a) Investigators involved in research are encouraged to acquire their own instruments for routine use from the funding for their research. Environmental Health and Safety will provide consultation on the selection of instruments for purchase. For special applications, survey meters may be loaned from Environmental Health and Safety.

8.15.5.2 Calibration / Repair

a) Environmental Health and Safety provides annual calibration for most survey meters by contracting with a vendor that is licensed to perform instrument calibration. The cost of repair or replacement of instruments damaged through misuse or careless handling is the responsibility of the laboratory.

b) The survey meter calibration documentation is retained for 3 years after the record is made[72].

8.15.5.3 Operational Checks

a) Prior to use, the survey meter should be checked to ensure it is operating properly. Never use a survey meter that is not fully operational. Check the:

(1) *Battery condition*. If low, change the batteries or consult with Environmental Health and Safety.

(2) *Calibration label*. The instrument should be calibrated within 1 year.

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[72] NUREG 1556 8.10.2 Radiation Monitoring Instruments

(3) *Meter response* with a check source on the side or stock vial.

8.15.5.4 Monitoring Procedures

a) Use the open window part of the probe for maximum detectability. Move the detector slowly about ¼ inch from the surface. Using the audio (if available) facilitates detection at background levels. Sporadic counts may be due to cable movement. Areas where this occurs should be monitored again with the detector movement suspended until the reading can be made. Questionable areas should be cleaned or swiped. Most meters read in either “mR/hr” or "cpm" or both.

8.15.5.5 Survey Action Levels

a) Any unlabeled area that clearly reads above background should be cleaned and resurveyed. Decontamination must be initiated if measured levels exceed 100 cpm or 0.1 mR/hr above background. If the contamination cannot be removed, notify the Authorized User and the Radiation Safety Officer. Also, the Authorized User and Radiation Safety Officer must be notified of any personal contamination.

8.15.6 RELEASING EQUIPMENT FOR REPAIR OR UNRESTRICTED USE

Labeled or potentially contaminated equipment may not be removed from a restricted area to an unrestricted area for any purpose (including repair, maintenance, disposal, or resale) until it is determined to be free of contamination by Radiation Safety personnel, who will document the release in writing. A copy of the release documentation should accompany the equipment to its destination. All radiation-warning labels must be removed from the equipment before it leaves the restricted area.

If the survey reveals evidence of contamination, the equipment will not be released until it has been decontaminated. Authorized Users are responsible for cleaning their equipment. Environmental Health and Safety will assist decontamination efforts upon request. Notify the Radiation Safety Officer if contamination cannot be removed.If repair of contaminated equipment is necessary, Radiation Safety personnel or an approved user will monitor the work to ensure that necessary precautions are observed.

8.15.7 RELEASING LABORATORIES FOR UNRESTRICTED USE

Any restricted laboratory or storage room requires a survey for contamination prior to releasing the area for unrestricted use. Radiation Safety personnel will survey all areas and equipment marked with "Radioactive Material" warning labels. The survey will randomly include other areas (counters, floors, equipment, desks, sink basins, and traps) for assurance. Potential storage areas (e.g., cabinets, drawers, refrigerators, and freezers) will be visually inspected for any item bearing a radiation-warning label. Once the lab is found to be free of radioactivity and contamination, all warning signs are removed and the Authorized User (or Department Chair if the Authorized User has left the university) is informed of the results in writing.

8.16 RADIOACTIVE SPILLS / EMERGENCY RESPONSE

8.16.1 RESPONSE TO MINOR SPILLS OF LIQUIDS AND SOLIDS (< 1 mCi)

a) Warn people in the area that a spill has occurred. Restrict uninvolved people from entering the area.

b) Prevent the spread of contamination by covering the spill with absorbent paper. Establish a boundary to the spill site. [Note: If the material evaporates quickly (e.g., a toluene solvent), turn on a nearby fume hood and vacate the area. Notify the Radiation Safety Officer as soon as possible.]

c) Wearing protective clothing (gloves, lab coat, eye protection, and shoe covers), clean up the spill with absorbent paper, soap and water, or a commercial decontamination agent. Place contaminated materials in radioactive trash.

d) Survey the area. Check the hands, clothing, and shoes of potentially contaminated persons for contamination.

e) Report the spill to the Authorized User and Radiation Safety Officer (Emergency Contact Phone Numbers).The Radiation Safety Officer will complete the Radioactive Spill Report.

f) Continue decontamination as needed.

g) Place all contaminated materials into properly labeled radioactive waste containers.

8.16.2 Response to Major Spills of Liquids And Solids (> 1 mCi)

a) Clear the area. Inform all persons not involved in the spill to leave the room.

b) Prevent the spread of contamination by covering the spill with absorbent paper, but do not clean it up. Prevent the spread of contamination by limiting the movement of persons who may be contaminated.

c) Close the room and lock (or otherwise secure) the area to prevent entry.

d) Immediately, notify the Radiation Safety Officer and Authorized User. The Radiation Safety Officer will supervise the clean-up and complete the Radioactive Spill Report.

e) Remove contaminated clothing and decontaminate affected persons.

8.16.3 Facility Decontamination

Users, under the direction of the Authorized User, are generally responsible for decontaminating laboratory equipment or spaces. The level of contamination should be assessed and preparations for decontamination should begin as soon as possible. Soap and water or commercial decontamination agents are able to reduce the contamination to acceptable levels in most cases. Should the contamination persist or the activity spilled be 1000s of dpm, obtain assistance from Environmental Health and Safety.

8.16.4 Personal Decontamination

a) Skin Decontamination. If contamination is found on the skin, **immediately** wash the contaminated area of the body for 2 to 3 minutes in warm water with a mild soap or a commercial cleaning agent *specifically designed for skin decontamination*. Avoid prolonged or coarse scrubbing that irritates the skin, which can increase absorption and inhibit further decontamination efforts. Notify the Authorized User and Radiation Safety Officer immediately after the decontamination effort. The Radiation Safety Officer may attempt more advanced decontamination techniques or perform a bioassay, if indicated.

b) Wound Decontamination. If an incident occurs where the skin is broken and contamination is evident, contamination of the wound should be suspected. Immediately notify the Authorized User and the Radiation Safety Officer. Cover the wound with gauze or a bandage, and cleanse the adjacent skin with soap and tepid water. Uncover the wound and wash the injured site with soap and tepid water. Monitor the wound and skin for residual contamination. If medical care is needed, see Medical Emergencies.

c) Internal Decontamination. Immediately notify the Radiation Safety Officer if internal contamination is suspected. Body surveys and bioassays (e.g., urine or fecal sampling) may be necessary. The treatment for internal contamination depends on the radioisotope and its chemical nature. Some dose reduction methods may involve administration of agents that reduce absorption, a large intake of fluids, or induction of vomiting. If medical care is needed, see Medical Emergencies.

d) Clothing Decontamination. Contaminated clothing must be removed as soon as a temporary change of clothes is available. Environmental Health and Safety will take possession of contaminated clothes and will return them to the owner either after decay or successful decontamination and monitoring. **Do not** use the university laundering facility for washing contaminated clothes or lab coats.

e) Report of Contamination. A report of contamination will be completed by the Radiation Safety Office, with input from involved parties, and forwarded to the Radiation Safety Committee for review. The report will include the circumstances leading to the incident, the chemical form, activity and method of assay of the radionuclide, how the accident occurred, and subsequent actions.

8.16.5 Medical Emergencies

Situations involving personal injuries may vary significantly. The outcome of an emergency depends largely on the discretion of those persons present. The following list of priorities prescribes general guidance for emergency actions. Don't Panic. The university procedures for injuries and illnesses are outlined in ***Wright Way Policy 13235***. Inform health care providers when contamination may be present so that they may utilize proper protective measures.

a) Remove the injured persons from imminent hazards (e.g., fire) and render first aid to save the victim's life or stabilize the injury. A person without life-threatening injuries, such as a broken arm, may be decontaminated before seeking medical assistance. Call the Radiation Safety Officer immediately.

b) **Report the injury (and hazardous condition, if one exists) to the Wright State Police Dispatch** (dial 911 or ext. 2111 or use an emergency telephone located in the corridors throughout campus). For off-campus laboratories, use medical facilities immediately available (e.g., Kettering Hospital or the VA Medical Center). If these facilities are not immediately available, call the local paramedics for assistance. The injured party should always be accompanied by a university employee whenever possible. Do NOT delay treatment for radioactive decontamination, unless the injury is not critical.

c) **Notify the Radiation Safety Officer and Authorized User** (Emergency Telephone Numbers). Brief the Radiation Safety Officer, upon his arrival, on the events that occurred, personnel involved and injured, and their disposition.

d) **Protect yourself from contamination** by wearing protective covering (e.g., gloves, boots, and lab coat).

e) Take steps to **prevent or minimize the spread of contamination** and make the patient comfortable. Restrict the entry of unnecessary persons into potentially contaminated areas. Detain potentially contaminated persons in a safe location.

f) **Do not attempt to fight a fire** unless it can be easily controlled and you are trained in the use of fire extinguishers. Avoid inhalation of smoke, fumes, and dust.

8.17 BIOASSAYS FOR INTERNAL EXPOSURE

a) Bioassays for measuring internal radiation exposure are performed whenever an intake of radioactive material is suspected, when a user may exceed 10% of the Annual Limit on Intake (ALI), a minor or declared pregnant woman may intake a committed effective dose of 50 mrem (0.5 mGy), or at the discretion of the Radiation Safety Officer.

8.17.1 Thyroid Bioassay

a) Approximately 30% of radioiodine taken in the body deposits in the thyroid gland. Thyroid bioassays are required before the first iodination procedure and after each procedure thereafter. This exam monitors the thyroid gland using a sodium iodide (NaI) detector. Post-iodination bioassays are performed between 24 and 72 hours after the procedure. An immediate bioassay should be performed if an intake of iodine is suspected, so that a thyroid-blocking agent can be administered, if necessary. *Any person who refuses to have a thyroid bioassay performed will not be allowed to take part in an iodination procedure.*

8.17.2 Bodily Waste Analysis

a) After an intake of radioactive materials has occurred, some of the unabsorbed materials are eliminated as waste and can be measured in the person's urine or feces, depending on the radioisotope. A urine sample is a relatively simple procedure that can determine intake. Any refusal to submit a sample for analysis must be documented.

8.17.3 Nasal and Throat Swabs

a) Swabs of the nasal opening and throat can indicate that an acute inhalation exposure has occurred. These samples may be taken by the Radiation Safety Officer following a suspected inhalation incident. Any refusal to submit to this procedure must be documented.

8.18 IODINATION PROCEDURES

8.18.1 Radioimmunoassay (RIA) Kits

Radioimmunoassay (RIA) kits have compounds labeled with ^{125}I and activities less than 10 μCi. A fume hood, survey meters, and bioassays are not usually required for using RIA materials.

When using materials in any form labeled with radioactive iodine in amounts greater than 10 μCi, additional protective measures may be warranted.

8.18.2 Iodination Procedures

An iodination process uses an unlabeled radioiodine to label a compound. This process typically utilizes millicurie quantities of ^{125}I and poses a genuine potential for exceeding the university release limits, contaminating laboratory personnel and spaces, or incurring an intake of radioactivity. For these reasons, the following requirements for iodinations apply:

a) Inform the Radiation Safety Officer at least 2 days in advance of each iodination procedure.

b) A thyroid bioassay must be performed on each participant before the first iodination. After each iodination thereafter, a follow-up thyroid bioassay must be performed between 24 and 72 hours of completion.

c) Inform the Radiation Safety Officer immediately if inhalation or personal contamination is suspected. If an intake is confirmed a potassium iodide blocking agent must be administered as soon as possible to mitigate exposure to the thyroid. The recommended KI dose is 1.4 mg/kg body mass [ref: Ribela, M.I., Health Physics, 76 (1): 11-16, 1999]. KI when given within 4 hours of exposure provides about 68% blocking effectiveness.

d) Prepare an "iodine trap" solution of 0.1 M each of sodium thiosulfate, sodium iodide, and sodium hydroxide if the iodination procedure is performed outside of the iodination glove box. This solution will trap free iodine for decontamination and disposal purposes.

e) The work must be performed in a fume hood, vented to the outside, with a minimal flow rate of 100 ft/min. The flow rate must have been certified within the past 12 months. Ensure the fan is on during the procedure. Keep the sash at a low, but comfortable position to maximize negative draw.

f) An iodination glove box with charcoal absorbers must be used to mitigate the release of 125I to the atmosphere. Ensure the fan works properly during the entire procedure.

g) A calibrated survey meter with a low-energy gamma detector is required. Frequent monitoring of gloves and around the fume hood should be performed to quickly identify contamination.

h) First practice the iodination procedures without radioactivity to become familiar with the steps involved and identify ways to reduce the potential of exposure.

i) Wear two pair of gloves to prevent absorption through the skin. Change the outer pair immediately if contaminated.

j) The Radiation Safety Officer may monitor the vented exhaust from the fume hood and the breathing zone of the person performing the iodination to ensure no limits are exceeded.

k) Keep contaminated trash in the fume hood as long as possible. Double bag the waste for pick-up by EHS.

l) Monitor gloves, exposed clothing, lab coat, and the work area (including the floor) for contamination after completion of work. Monitor and wash hands before leaving the lab.

m) Survey the use area for removable contamination following the iodination procedure.

n) Notify the Radiation Safety Officer if personal or laboratory contamination is suspected.

8.19 SEALED RADIOACTIVE SOURCES

A sealed source is a contained source that has been constructed and tested to pass specific accident conditions without the release of radioactive material. The manufacturer or distributor for each sealed source performs a safety evaluation which is documented in a Sealed Source and Device (SSD) Registration Certificate.

Sealed sources are controls to prevent unplanned exposures and loss of sources. Wright State requires that all sealed radioactive sources (both accountable and exempt) shall be used, handled, and stored in a manner commensurate with the hazards associated with operations involving the sources[73]

For accountable sealed radioactive sources specific measures, including inventories and source leak tests, shall be implemented[74]

Exempt sealed sources need not be inventoried and leak tested. However, exempt sealed sources and the individuals using them are still subject to all other applicable requirements of 10 CFR 835 (e.b., radioactive material control, posting and labeling, radiation safety training, etc.).

For radionuclides that are not listed

8.19.1 Receipt of Sealed Sources

Wright State's Radioactive Material License (Item 14) states that all sealed sources that are used or obtained shall have been evaluated or approved under the provision of OAC 3701:1-46-49, or equivalent NRC or Agreement State regulation[75]. Therefore, all sealed sources must be approved by the RSO prior to the purchase to meet the requirement of the license. The approval must be documented by submission of RSO-03

Any additional sealed sources that are not approved by Wright State's current license must be submitted by the RSO to ODH as an amendment to the license, prior to arrival to Wright State's campus.

[73] 10 CFR § 835.1201

[74] 10 CFR § 835.1202

[75] OAC 3701:1-14-49 Registration of product information

Wright State's Radioactive Material License (Item 15) requires that sealed sources shall be tested for leakage and/or contamination in accordance with OAC 3701:1-38-24[76].

8.19.2 Inventory of Sealed Sources

The inventory of sealed sources shall be conducted at least every three or six months[77].

Type of Sealed Source	Inventory Frequency
Not designed to emit alpha particles	Not to exceed 6 months[78]
Designed to emit alpha particles	Not to exceed 3 months[79]
Sources in storage	Not to exceed 6 months
Exempt sealed radioactive sources	Not required

8.19.3 Leak Tests of Sealed Sources

Sealed sources shall be tested in accordance with OAC 3701:1-38-24 Testing for leakage or contamination of sealed sources[80].

8.19.3.1 Sealed Source Leak Test Procedure

Leak tests of sealed sources shall be performed in accordance with OAC 3701:1-38-24 Testing for leakage or contamination of sealed sources[81] and the leak tests must be done according to the manufacturer's instructions.

A leak test sample is collected by using a small standard laboratory wipe, a leak test sample should be collected at the most accessible area where contamination would accumulate if the source were leaking. The source should not be exposed to do the leak test. A sealed source fails the leak test if the contamination on the filter paper or swab used for the test exceeds 0.005 microcuries.

8.19.3.2 Sealed Source Leak Test Frequency

Sealed sources must be leak tested by the Environmental Health and Safety upon receipt[82] and every three or six months.

Table 10. Type of Sealed Source and Frequency of Testing

Type of Sealed Source	Test Frequency
Not designed to emit alpha particles	Not to exceed 6 months[83]
Designed to emit alpha particles	Not to exceed 3 months[84]
Suspected of damage, leakage or contamination	Before further use
Sources in storage	Before use or transfer[85;] Recommended every 5 years
Exempt sealed radioactive sources	Not required

[76] OAC 3701:1-38-24 Testing for leakage or contamination of sealed sources.
[77] OAC 3701:1-38-24 (A)(1) Testing for leakage or contamination of sealed sources
[78] OAC 3701:1-38-24 (A)(2) Testing for leakage or contamination of sealed sources
[79] OAC 3701:1-38-24 (A)(3) Testing for leakage or contamination of sealed sources
[80] OAC 3701:1-38-24 Testing for leakage or contamination of sealed sources.
[81] OAC 3701:1-38-24 Testing for leakage or contamination of sealed sources.
[82] OAC 3701:1-38-24 (A)(1) Testing for leakage or contamination of sealed sources
[83] OAC 3701:1-38-24 (A)(2) Testing for leakage or contamination of sealed sources
[84] OAC 3701:1-38-24 (A)(3) Testing for leakage or contamination of sealed sources
[85] OAC 3701:1-38-24 (B)(6) Testing for leakage or contamination of sealed sources

8.19.3.3 Sealed Source Detection Limit

The method of testing must be able to detect the presence of 0.005 μCi, which is the Ohio Department of Health action level[86]. Should this level be met or exceeded, the source will be removed from service for decontamination, repair, or disposal. The event must be reported to the Ohio Department of Health within 5 days.

8.19.3.4 Sealed Source Leak Testing Exemptions

The following sealed sources are exempted from the leak testing requirement[87]:

- Sealed sources containing only radioactive material with a half-life of less than thirty days[88];
- Sealed sources containing only radioactive material as a gas[89];
- Sealed sources containing 3.7 megabecquerels (one hundred microcuries) or less of beta or photon emitting material or three hundred seventy kilobecquerels (ten microcuries) or less of alpha-emitting material[90];
- Sealed sources containing only hydrogen-3[91];
- Seeds of iridium-192 encased in nylon ribbon[92]; and
- Sealed sources which are stored, not being used and identified as in storage. However, each such sealed source will be tested for leakage or contamination and receive the test results before any use or transfer unless it has been tested for leakage or contamination within six months before the date of use or transfer[93]. T

When a non-exempt sealed source is removed from storage, it shall be leak tested before use or transfer[94]. However, Wright State recommends that stored sealed sources shall be leak tested at least every 5 years.

8.19.3.5 Leaking Sealed Source

A leaking sealed source shall be immediately withdrawn from use and action be taken to prevent the spread of contamination. The sealed source shall be repaired or disposed of in accordance with rule 3701:1-38[95]

The licensee shall immediately withdraw a leaking sealed source from use and shall take action to prevent the spread of contamination. The leaking sealed source shall be repaired or disposed of in accordance with this chapter[96].

8.19.3.6 Records of Leak Tests and Inventory of Sealed Sources

Reports of test results for leaking or contaminated sealed sources shall be made pursuant to paragraph (F) of rule 3701:1-38-21 of the Administrative Code[97].

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[86] OAC 3701:1-38-24 (A)(5) Testing for leakage or contamination of sealed sources
[87] OAC 3701:1-38-24 (B)(1) Testing for leakage or contamination of sealed sources
[88] OAC 3701:1-38-24 (B)(1) Testing for leakage or contamination of sealed sources
[89] OAC 3701:1-38-24 (B)(2) Testing for leakage or contamination of sealed sources
[90] OAC 3701:1-38-24 (B)(3) Testing for leakage or contamination of sealed sources
[91] OAC 3701:1-38-24 (B)(4) Testing for leakage or contamination of sealed sources
[92] OAC 3701:1-38-24 (B)(5) Testing for leakage or contamination of sealed sources
[93] OAC 3701:1-38-24 (B)(6) Testing for leakage or contamination of sealed sources
[94] OAC 3701:1-38-24 (B)(6) Testing for leakage or contamination of sealed sources
[95] OAC 3701:1-38 General Radiation Protection standars for Sources of Radiation
[96] OAC 3701:1-38-24 (F) Testing for leakage or contamination of sealed sources
[97] OAC 3701:1-38-24 (G) Testing for leakage or contamination of sealed sources

A report of a leaking or contaminated sealed source shall be filed by Wright State to the Ohio Department of Health within five days of the test results[98], if the test reveals the presence of one hundred eighty-five becquerels (0.005 microcurie) or more of removable contamination. The report shall include the equipment involved, the test results and the corrective action taken.

The Department of Environmental Health and Safety shall retain records of leak tests required by for 3 years[99]. The records must include the model number, and serial number if one has been assigned, of each source tested; the identity of each source by radionuclide and its estimated activity; the results of the test; the date of the test; and the name of the individual who performed the test.

The Department of Environmental Health and Safety shall retain records of the semi-annual physical inventory of sealed sources and brachytherapy sources for 3 years[100]. The inventory records must contain the model number of each source, and serial number if one has been assigned, the identity of each source by radionuclide and its nominal activity, the location of each source, and the name of the individual who performed the inventory.

8.19.4 Gas Chromatography Equipment

Electron capture detectors available on some gas chromatography units contain radioactive foils used to ionize the carrier gas. The foil, which contains 15 mCi or less of ^{63}Ni, is contained in a detector cell. The carrier gas enters the bottom of the cell, passes by the radioactive foil, and exhausts at the top. The exhaust must be vented to the outside. An effluent trap may be used to capture exhaust vapors, if approved by the Radiation Safety Officer.

The radioactive source shall not be removed from the electron capture device. In order to ensure the integrity of the detector foil, adhere to the manufacturer's guidelines for use. The detector can only be cleaned under the direction of the Authorized User using procedures established by the manufacturer. Inform the Radiation Safety Officer each time that this procedure will be performed so that the source may be leak tested after the cleaning process.

If damage to the detector is suspected, immediately notify the Authorized User and the Radiation Safety Officer.

A test for source leakage and radioactive contamination should be performed before removing a potentially damaged source. A contaminated electron capture device must be handled with caution to prevent the spread of contamination. After the detector has cooled, remove it with gloved hands. Wrap the gloves around the electron capture device after removal to contain any contaminants.

8.20 ANIMAL USAGE INVOLVING RADIOACTIVE MATERIALS

If facilities of the Laboratory Animal Resources department are to be used for housing, care, or feeding of animals contaminated with radioactive material, Form LAR/RSO-14, "Animal Care Information", must be completed and signed. It is submitted with the Use Authorization application, Form RSO-03, to Environmental Health and Safety and Director of Laboratory Animal Resources for approval. Handling and disposal should be clearly addressed on the Use Authorization application, Form RSO-03. Experimental animals shall not be used for human consumption.

The Authorized User must ensure that the presence of radioactivity and specific instructions are fully communicated to lab animal staff by ensuring the following requirements are met.

a) Posting. The entryway to a room holding contaminated animals shall be posted with a "Caution: Radioactive Materials" sign.

b) Instructions. Instructions for caretakers must be posted on or near the animal cages. A Lab Animal Information Notice fulfills this requirement when completed and signed. The instructions should address relevant information

[98] OAC 3701:1-38-24 (F) Testing for leakage or contamination of sealed sources

[99] OAC 3701:1-38-20(E) Records.

[100] Oc.

regarding personal protection, dosimetry, feeding, changing bedding, disposition of dead or ill animals, and any special directions required for experimental control.

c) Labeling. Cages housing contaminated animals, waste containers, and any potential contaminated equipment must be properly labeled with "Caution: Radioactive Material" tape. The labels on cages and waste should indicate the isotope, date (or beginning date) of administration, estimated activity of radioactive material, and the Authorized User.

d) Containment. Radioactive animal waste must be contained by using under pads, collecting urine, or other means, as appropriate.

e) Survey/Decontamination/Cleaning. The warning labels on potentially contaminated cages should be removed just before being washed. Environmental Health and Safety will survey potentially contaminated equipment upon request.

f) Transport. Movement of contaminated animals through uncontrolled areas of the University is discouraged. If necessary, Form RSO-03 will specify precautions to be taken to prevent contamination of uncontrolled areas and unnecessary exposure of anyone in these areas.

8.21 RADIOACTIVE WASTE

Safe disposition of radioactive waste materials comprises an essential component of the Radiation Safety Program and regulatory compliance. The Authorized User is responsible for ensuring that radioactive waste is properly contained, labeled, and disposed. Each proposed Use Authorization application must address the types of radioactive waste expected to be generated and the disposal methods. Contact Environmental Health and Safety if you have any questions regarding disposal of any specific waste.

8.21.1 Containment and Labeling of Waste

Radioactive waste bears the same precautions as the radioactive materials. The materials must be properly contained to prevent spills or breakage. The type of container is specific to the type of material. Correct labeling of the waste container is essential to ensure that the contents are identified and that the material is not mistakenly discarded as regular trash. Materials that comprise of high-energy β or γ emitters should be shielded to reduce exposure to laboratory personnel.

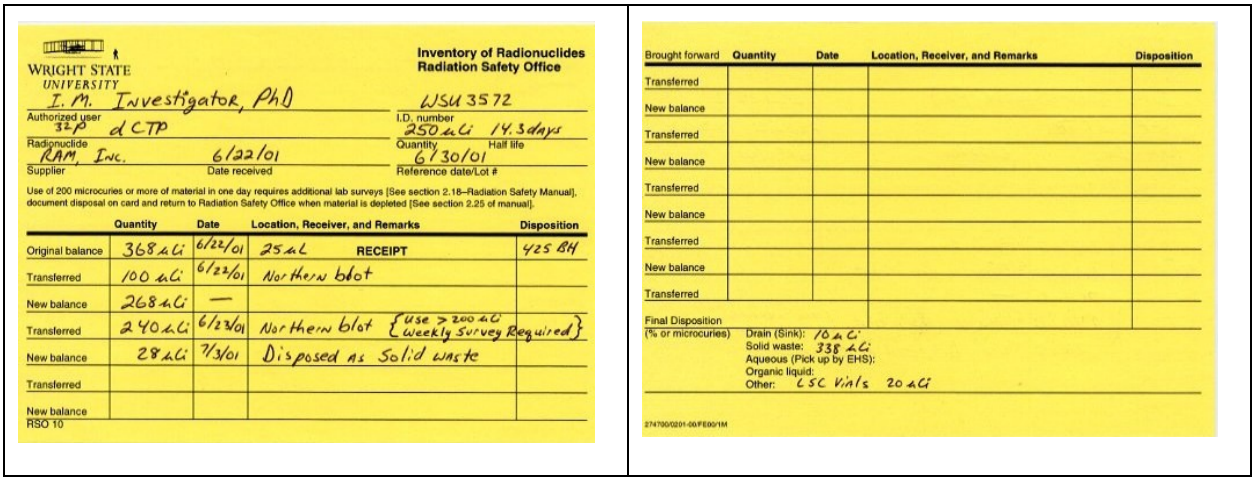
Figure 10. Example of radioactive material waste label.

8.21.2 Disposal Records

Documentation of waste disposal is mandatory for regulatory compliance. Waste disposal records must be retained indefinitely. Authorized Users must ensure that the distribution of disposed radioactive waste is accurately communicated to Environmental Health and Safety. The most effective means of accomplishing this is recording distribution information on the yellow Inventory Card (RSO-10). The yellow Inventory Card (RSO-10) is returned to the Radiation Safety Office when the radioactive material is expended.

8.21.2.1 Documentation on the Inventory Card.

a) As radioactive waste is disposed, the means of disposal should be summarized on the Inventory of Radionuclides (Yellow) Card (Form RSO-10). The summary should identify the waste method (e.g., drain or sink, solid, liquid, organic scintillation, mixed waste) and estimated activity or percentage of activity for each disposal route.



WRIGHT STATE UNIVERSITY

Inventory of Radionuclides
Radiation Safety Office

Authorized user: I. M. Investigator, PhD — I.D. number: WSU 3572
Radionuclide: 32P dCTP — Quantity: 250 µCi — Half life: 14.3 days
Supplier: RAM, Inc. — Date received: 6/22/01 — Reference date/Lot #: 6/30/01

Use of 200 microcuries or more of material in one day requires additional lab surveys [See section 2.18–Radiation Safety Manual], document disposal on card and return to Radiation Safety Office when material is depleted [See section 2.25 of manual].

	Quantity	Date	Location, Receiver, and Remarks	Disposition
Original balance	368 µCi	6/22/01	25 µL RECEIPT	425 BH
Transferred	100 µCi	6/22/01	Northern blot	
New balance	268 µCi	—		
Transferred	240 µCi	6/23/01	Northern blot {use > 200 µCi Weekly Survey Required}	
New balance	28 µCi	7/3/01	Disposed as Solid waste	
Transferred				
New balance				

RSO 10

Brought forward	Quantity	Date	Location, Receiver, and Remarks	Disposition
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				
Transferred				
New balance				
Transferred				

Final Disposition (% or microcuries)
Drain (Sink): 10 µCi
Solid waste: 338 µCi
Aqueous (Pick up by EHS):
Organic liquid:
Other: 6 SC Vials 20 µCi

274700/0201-00/FE00/1M

Figure 11. Example of disposal documentation on inventory card.

8.21.2.2 Labeling

a) All waste containers submitted to the Radiation Safety Office for disposal must be tagged with a label appropriate for the waste contents. When properly completed, these labels provide the information needed for proper disposition. Labels for solid, liquid, scintillation vial, and animal wastes are available from the Radiation Safety Office. For waste contaminated with short half-life material (<120 days) and with consideration for ALARA, remove or deface radiation labels before discarding the waste into radioactive trash. This will help the Radiation Safety Office with the disposal process.

8.21.3 Waste Minimization

The high cost of radioactive waste disposal and the spirit of efficient utilization of resources require practical and cautious means of reducing waste volume, primarily by minimizing waste generation. Some methods are:

a) substituting non-radioactive compounds or radioisotopes with half-lives less than 120 days where practicable.

b) carefully segregating radioactive waste from non-radioactive waste.

c) separating short-lived radioactive waste (i.e., half-life less than 90 days) from long-lived radioactive waste (i.e., half-life greater than 120 days).

d) avoiding unnecessary contamination of items during the use of radioactive materials.

e) purchasing the minimum amount of radioactivity needed for experimental purpose.

f) decontaminating materials.

g) avoiding generation of mixed waste.

8.21.4 Solid Waste

Solid, non-reusable waste, such as contaminated absorbent paper, gloves, empty containers, must be placed in the plastic bag-lined poly bucket, supplied by the Radiation Safety Office. Consider double bagging waste that

Figure 12. Example of radioactive waste labe for liquid scintillation vials.

contains millicurie levels of radioactivity. **IMPORTANT:** Do *NOT* place sharp objects such as syringe needles or razor blades in waste bags. Doing so could result in injury and contamination of personnel. Always discard needles in a properly labeled sharps container that is not used for chemical or biological waste purposes.

Solid, breakable, non-reusable waste, such as contaminated glass pipettes and beakers must be placed in an appropriate container, such as a poly-lined box. The added support will prevent personal injury or internal contamination should the material break.

a) Pick-up. When the container is sealed and properly labeled, contact Environmental Health and Safety by completing the on-line EHS Request Form to remove the waste.

b) Disposal. Environmental Health and Safety will dispose of the material according to its half-life. Materials with a half-life less than 120 days are held for decay-in-storage and materials with half-lives greater than 120 days are disposed as low-level radioactive waste.

8.21.5 Liquid Waste

The disposal method for liquid radioactive waste depends on its solubility in water and its EPA hazard class. Liquid waste intended for pick-up by Environmental Health and Safety personnel must be placed in a sealed, non-leaking container (e.g., capped plastic or glass bottle) and tagged with a properly completed Liquid Waste label available from Environmental Health and Safety.

a) Liquid Waste Soluble in Water. Liquid radioactive waste that is soluble in water may be disposed into the sewer system providing the following conditions are met. Short-lived material (i.e., half-life less than 120 days) can be held for decay to minimize the activity released.

   (1) The liquid must be readily soluble in water. Compounds described in the Handbook of Chemistry and Physics as Very Soluble (VS) or Soluble (S) fulfill this requirement. NOTE: Readily dispersible biological material is also allowable with approval from the Radiation Safety Officer;

   (2) The sink used must be designated as a "Hot Sink" and labeled as such; and

   (3) The liquid must not be a hazardous waste that would violate disposal regulations of the EPA. Contact Environmental Health and Safety if the waste may fall into this category.

b) Monthly disposal limit per lab. Contact the Radiation Safety Officer if you may exceed these values:

   (1) Tritium (^{3}H): 1000 μCi (1 mCi, 37 MBq)

   (2) Carbon-14 (^{14}C): 500 μCi (0.5 mCi, 18.5 MBq)

   (3) All other radionuclides combined: 500 μCi (0.5 mCi, 18.5 MBq)

Table 11. Monthly drain disposal limits for radioactive material.

Radioactive material	Monthly disposal limit
H-3	1000 μCi (1 mCi, 37 MBq)
C-14	500 μCi (0.5 mCi, 18.5 MBq)
All other radionuclides combined	500 μCi (0.5 mCi, 18.5 MBq)

a) Liquid Waste **NOT** Soluble in Water. Liquid radioactive waste that is *NOT* soluble in water must be picked up by Environmental Health and Safety for disposal.

8.21.6 Liquid Scintillation Vials

The disposal method for liquid scintillation vials depends on the type of scintillation fluid and the concentration of activity.

Scintillation vials must be securely capped to prevent leakage. Vials disposed through Environmental Health and Safety must be in a vial tray (or otherwise stored upright in a box) that is properly labeled with the AU number, isotope, date, and activity.

a) Biodegradable Liquid Scintillation Fluid. Before disposing of a scintillation fluid marketed as biodegradable down a sink as liquid waste, verify the material is suitable for sewer disposal by contacting Environmental Health and Safety for approval. Once clearance is obtained, sink disposal is acceptable providing no solids or insoluble materials are released into the sink. The empty vials must be rinsed out three or more times before disposal in regular trash.

b) Organic Liquid Scintillation Fluid. Organic or non-biodegradable scintillation fluid must be picked up by the Radiation Safety Office for disposal.

c) Exempted Levels of Activity. Liquid scintillation vials containing ^{3}H or ^{14}C with activities less than 0.05 μCi per gram of scintillation fluid may be disposed as if they were not radioactive. Any vials that are to be picked-up by the Radiation Safety Office must be properly labeled regardless of exempted status.

8.21.7 Decay-In-Storage (DIS)

a) The university may hold materials with half-lives of less than 120 days for decay-in-storage. The material must be held for 10 half-lives. A survey must be performed to verify that the material cannot be discerned from background. All radiation labels must be removed or obliterated prior to disposal as normal trash.

b) Records of Disposal. A record of each disposal must be held for at least 3 years[101], [102].[103] The record must include the:

   (1) disposal date,

   (2) radionuclides disposed,

   (3) survey instrument used,

   (4) background dose rate,

   (5) dose rate measured at the surface of each container, and

   (6) name of the person who performed the disposal.

c) Wright State shall retain disposal records until ODH terminates each pertinent license that requires the record[104]

8.21.8 Animal Waste

a) Containment. Animal carcasses, excrement, and associated wastes containing radioactivity will be wrapped in absorbent paper, placed in a plastic bag, and refrigerated or frozen. Double bagging and packaging in a box or can is encouraged when one bag may not hold the waste. Contact Environmental Health and Safety for disposal.

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[101] OAC 3701:1-38-20(K) Records.

[102] OAC 3701:1-38-19(E)(3) Waste disposal.

[103] OAC 3701:1-38-19(G) Waste disposal.

[104] OAC 3701:1-38-20(K) Records.

b) Labeling. The container of contaminated animal matter must be tagged with an Animal Waste label available from Environmental Health and Safety.

c) Exempted Levels of Activity. Animal waste containing ^{3}H or ^{14}C with activities less than 0.05 μCi per gram of animal tissue averaged over the entire animal may be disposed as if the material were not radioactive. Waste meeting these criteria should be addressed in the user's Use Authorization or in supplementary documentation.

8.21.9 Mixed Waste

Mixed waste is radioactive waste that also contains other hazardous materials regulated by the EPA. These materials must be segregated from other waste streams in suitable containers bearing Liquid Waste labels. On the label list the contents and percent composition. Acids should be neutralized, unless the neutralization process may release radioactive gases. Volatile materials that are flammable, explosive, or sublimate require extra caution. Any extra care required in handling must be indicated on the container.

8.21.10 Infectious Waste

Radioactive, infectious agents should be inactivated or neutralized prior to release for disposal as radioactive waste. The Use Authorization for usage should address the proposed process for neutralization and disposal.

9 RADIATION GENERATING EQUIPMENT (RGE)

9.1 INTRODUCTION

The policies and procedures of the Radiation Safety Manual apply to the use of radiation generating equipment (RGE) governed by Chapters 3701:1-38[105], 3701:1-66[106], and 3701:1-68[107] of the Ohio Administrative Code (OAC). All radiation-generating equipment, whether active or in storage, must be registered with Ohio Bureau of Radiation Protection.

Radiation-generating equipment (RGE), also known as radiation-producing devices (RPD), consist of a wide variety of devices such as diagnostic, veterinary, and analytical x-ray units, as well as particle accelerators that are used for specific purposes in research and/or patient care. These facilities differ broadly in their potential for harm. This manual provides general guidance for safety and usage. Required operating procedures for each facility give more detailed information and procedures relevant to safety and regulatory compliance. The provisions of the Radiation Safety Manual and the operating procedures for each device constitute the Quality Assurance Program required by OAC 3701:1-66-04[108] and OAC 3701:1-68-02[109].

9.2 USERS OF RADIATION GENERATING EQUIPMENT (RGE)

Radioactive materials can only be used by permitted users. Users are approved based on their role, training, education, and experience. At Wright State, radioactive materials are classified as:

a) Facility Coordinator

b) Faculty User

c) Facility Operator

d) Medical Operator

e) Student Operator

9.2.1 Facility Coordinator

A Facility Coordinator shall be named for each facility utilizing radiation-generating equipment (RGE). The Facility Coordinator administratively oversees and coordinates radiation-generating equipment operations and maintenance to ensure appropriate and safe usage. Additionally, the Facility Coordinator serves as a conduit for communications between Radiation Safety personnel and the Faculty Users in matters concerning the radiation-generating equipment facility operations and safety.

9.2.1.1 FACILITY COORDINATOR QUALIFICATIONS

The Chair of the department housing the radiation-generating equipment facility nominates the prospective Facility Coordinator for approval by the Radiation Safety Officer. The Facility Coordinator must be a faculty member (teaching or research) who has sufficient knowledge, experience, and administrative authority to reasonably assure safety, oversight, and control of the radiation-generating equipment.

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[105] OAC 3701:1-38 General Radiation Protection Standards for Sources of Radiation

[106] OAC 3701:1-66 Radiation Generating Equipment

[107] OAC 3701:1-68 Industrial Radiation Equipment

[108] OAC 3701:1-66-04 Quality assurance program for medical radiation-generating equipment

[109] OAC 3701:1-68-02 General requirements

9.2.1.2 FACILITY COORDINATOR RESPONSIBILITIES

a) Develop operating procedures for the facility that satisfy the requirements from OAC 3701:1-66[110] (for Radiation Generating Equipment) and OAC 3701:1-68[111] (for Industrial Radiation Generating Equipment). The Radiation Safety Manual and Operating Procedures must be accessible to radiation-generating equipment operators at all times.

b) Operating procedures must contain site-specific instructions, as well as manufacturer's instructions. The operating procedures must be reviewed periodically to ensure they are current. Faculty Users must communicate any change in operating status of the device or required operating procedures to the Radiation Safety Officer. Changes must be documented within the operating procedures, in addition to a memorandum to the Radiation Safety Officer.

c) Establish and administer controls limiting access to each device to approved operators, as well as scheduling the use of radiation-generating equipment.

d) Develop and maintain a use log for each radiation-generating equipment. Use log templates are available through Environmental Health and Safety, upon request.

e) Develop training programs for operators and any individual likely to receive a radiation exposure rate of 0.1 mrem/hr, not to exceed 100 mrem in a calendar year from the facility. Training will include general radiation safety training offered by the Radiation Safety Officer for all operators and users (see "Training Requirements" for details).

f) Sign off on the adequacy of training and experience for Faculty Users, Facility Operators, Medical Operators, Student User, and Visitor User, for institutional accountability and quality assurance. There is a line on the forms for this signature.

g) Arrange for appropriate maintenance of each device and schedule housekeeping services for the facility. ***A record of maintenance is required.***

h) Ensure that regular tests are made to verify the functioning of safety features as specified in the operating procedures. This includes the quarterly quality assurance check of the warning lights and interlock systems for each piece of radiation-generating equipment. ***Record results in user's log.***

i) Arrange with the Radiation Safety Officer for periodic surveys of the safety features of each device, and keep the Radiation Safety Officer informed of any changes that would affect the radiation output or safety aspects of any device.

j) Inform the Radiation Safety Officer prior to the acquisition of additional or upgraded equipment or removal from service of old equipment to ensure that registrations with the Ohio Bureau of Radiation Protection are kept current.

k) Immediately inform the Radiation Safety Officer and Department Chair of any situation resulting in or that could have resulted in personal injury.

l) Inform the Radiation Safety Officer and Faculty Users of any significant modifications to existing equipment, facility alterations, or construction near the facility that may affect personnel safety or the adequacy of shielding.

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[110] OAC 3701:1-66 Radiation Generating Equipment

[111] OAC 3701:1-68 Industrial Radiation Equipment

m) Complete EHS general radiation safety training for radiation-generating equipment, first initially, and annually thereafter, for as long as the Use Authorization is active.

n) Name an interim facility coordinator in the event of sabbatical leave or any other situation when the Facility Coordinator is on an extended leave away from the university. The Radiation Safety Officer must be informed prior to such leave.

9.2.2 INTERIM FACILITY COORDINATOR

An Interim Facility Coordinator is named when the Facility Coordinator is on extended leave away from the university. The Facility Coordinator must complete

9.2.3 FACULTY USER

A Faculty User is a departmentally affiliated member of Wright State University, authorized by the Radiation Safety Officer, to use specific radiation-generating equipment independently and supervise subordinate operators. Research Use Authorizations must be submitted for approval before use of the radiation-generating equipment.

Operation of radiation-generating equipment must fully comply with research Use Authorizations approved by Environmental Health and Safety. The Faculty User is responsible for the safe use of the equipment, including operation by anyone under his/her direction and protection of other personnel. Additionally, the Faculty User shall ensure that subordinate operators are familiar with Operating Procedures, have proper training to safely perform each assigned task, and can respond appropriately to emergency situations. Radiation-generating equipment use in research with human subjects must have approval from WSU's Institutional Review Board. Clinical and research use of radiation-generating equipment on human subjects must also obtain Radiation Safety Officer approval.

9.2.3.1 FACULTY USER QUALIFICATIONS

A prospective Faculty User must apply to the Radiation Safety Officer for approval. The applicant shall submit his/her training and experience on Form RSO-02. The Faculty User must:

a) have 40 hours of training and experience operating similar radiation-generating equipment;

b) have access to a Radiation Safety Manual;

c) review the manual, facility operating procedures and applicable Ohio Bureau of Radiation Protection rules with the Radiation Safety Officer, while paying close attention to Faculty User responsibilities, operator training, and other issues related to radiation-generating equipment usage and safety;

d) ensure the training requirements for facility operator are fulfilled.

The Faculty User's experience with radiation-generating equipment should be reasonably current. The Radiation Safety Officer will judge the adequacy and currency of experience on a case-by-case basis.

An applicant who is otherwise qualified may gain experience using radiation-generating equipment as an operator under the supervision of an approved Faculty User. Upon written recommendation by the supervising Facility Coordinator, the Radiation Safety Officer may upgrade the applicant's status to Faculty User.

9.2.3.2 FACULTY USER RESPONSIBILITIES

a) Ensure that operation, including that by subordinate operators, is compliant with the provisions of the facility operating procedures, approved Use Authorizations, and the Radiation Safety Manual.

b) A Faculty User's Use Authorization to use radiation-generating equipment is not transferable to another Faculty User, unless approved by the Radiation Safety Officer. For instance, the research of a Faculty User planning to

go on sabbatical cannot be continued unless another Faculty User accepts the research and approved by the Radiation Safety Officer for a similar Use Authorization. The Faculty User is responsible for asking the Radiation Safety Officer to suspend a Use Authorization and make arrangements for continued work by subordinates under another Faculty User (as appropriate). If the Faculty User is to be absent from campus for more than 4 consecutive weeks.

c) Provide sufficient training and supervision to subordinate operators such that they operate the device safely. The training must be documented on Form Radiation Safety Officer or a similar form designated in the Operating Procedures. Bystanders or visitors who may receive up to 100 mrem per year have must complete and document training on the Laboratory Hazard Instruction form.

d) Never allow operation of radiation-generating equipment when unsafe conditions are evident. Do not operate radiation-generating equipment or immediately cease operations if a malfunction occurs that may affect safety (e.g., burnt out warning light, interlock failure, water near high voltage sources). Refrain from operations until the problem or malfunction is corrected. Take positive steps (e.g., post a "DO NOT USE" sign, "lock out/tag out" the unit) to ensure the unit is not used prior to repair. Immediately inform the Facility Coordinator.

e) Keep the Radiation Safety Manual and Operating Procedures accessible to operators. Ensure operators under the Faculty User's direction are familiar with the emergency procedures for radiation-generating equipment.

f) Submit Use Authorizations to the Radiation Safety Officer for research projects using the radiation-generating equipment and perform only projects that fall under the umbrella of an approved Use Authorization.

g) Keep Use Authorizations current as procedures and operators change. Send updated information to the Radiation Safety Officer by memorandum. Review all current Use Authorizations for accuracy and any change that may affect radiation safety at least annually.

h) Ensure all operators have appropriate dosimetry devices (e.g., OSLDs, finger rings, direct-read dosimeters) and check regularly on their use.

i) Before operating any radiation-generating equipment, visually check and clear anyone in the exposure room (the room housing the radiation-generating equipment or its active element) who may be unnecessarily exposed to radiation. The visual check and clearing of people from the exposure room must be done prior to each use of the radiation-generating equipment.

j) Inform the Radiation Safety Officer and Facility Coordinator immediately of any safety related incident that has or could have resulted in personal injury, even if it occurs after normal working hours.

k) Ensure that facility logbook entries are recorded for routine use and "notable" events; e.g., malfunctions and repairs, unusual operating conditions. The use of electronic logs is acceptable if this is what the system uses.

l) Ensure that the radiation-generating equipment is left with power "off" and locked after use with equipment and door to facility secured against unauthorized use.

m) Complete the required EHS general radiation safety training for radiation-generating devices, first initially, and annually thereafter, for as long as the Use Authorization is active.

9.2.4 FACILITY OPERATOR

A Facility Operator is a departmentally affiliated member of the university, who operates radiation generating equipment for research purposes under the direction of a Faculty User with a limited degree of independence. The Facility Operator is responsible for the safe performance of his/her own activities. The Facility Operator can assist the Faculty User with training new operators in the lab. The Faculty User must apply to the Radiation Safety Officer to add a person to his/her Use Authorization as a Facility Operator. The Radiation Safety Officer grants approval of

Facility Operator status based on completion of the operator's training. The Radiation Safety Officer may approve persons who are clearly qualified.

9.2.4.1 FACILITY OPERATOR TRAINING

The supervising Faculty User must:

a) Submit the prospective operator's prior training and experience on Form RSO-02 to the Radiation Safety Officer.

b) Provide and document training to each new operator on the topics addressed in the Operating Procedures. The operator completion form must be used to document laboratory-specific and operational training specific to each radiation-generating device.

c) Provide direct (observed) supervision for each operation until the Faculty User is confident that the prospective operator complies with the Operating Procedures and can work independently. The period of supervision depends on the perspective operator's performance and previous experience with similar devices. Experience must be documented on the operator completion form and signed by the Facility Coordinator.

d) When training is complete, add the individual to the Faculty User's authorization by submitting a memorandum to the Radiation Safety Officer for approval/review.

9.2.4.2 FACILITY OPERATOR RESPONSIBILITIES

a) Operate only radiation-generating equipment for which approval has been granted.

b) Adhere to the safety rules and regulations as promulgated in this manual, facility Operating Procedures, and any communications from Environmental Health and Safety and the Radiation Safety Officer.

c) Wear issued radiation dosimeters when the radiation-generating equipment is operating. Return the dosimeters to Environmental Health and Safety when use is discontinued.

d) Operate the radiation-generating equipment in such a way as to keep radiation exposures As Low As Reasonably Achievable (ALARA).

e) Before operating radiation-generating equipment, visually check and clear anyone from the exposure room [the exposure room is the room in which the radiation-generating equipment is located] who may be unnecessarily exposed to radiation.

f) Ensure that the radiation-generating equipment is left with power "off" after use with equipment. Remove key, if possible, or lockout/tag out equipment. Make sure the door to facility secured against unauthorized use.

g) Inform the Radiation Safety Officer and the Faculty User immediately of any safety related incident that has or could have resulted in personal injury, even if it occurs after normal working hours.

h) Ensure that facility logbook entries are recorded for routine use and for "notable" events; e.g., malfunctions

i) Report any malfunctions or unusual operating conditions to the responsible Faculty User and the Facility Coordinator.

j) Complete EHS general radiation safety training for radiation-generating equipment, first initially, and annually thereafter, for as long as the Use Authorization is active.

9.2.5 MEDICAL OPERATORS

a) A Medical Operator is a departmentally affiliated member of the university who uses radiation-generating equipment under the direction of a Faculty User approved for clinical or research use on human subjects.

b) All use of radiation-generating equipment on live humans **MUST** have an approved Institutional Review Board

c) Use Authorization when using equipment for research purposes.

d) A Medical Operator must hold either a Radiographers or an X-ray Machine Operators license issued by the Ohio Department of Health to operate an x-ray unit used to expose humans, excluding cadavers, to the primary beam.

e) The Medical Operator is responsible for the safety of the patient, compliance with the facility operating procedures, and acting in a safe manner.

f) The Faculty User must apply to the Radiation Safety Officer to add a person to his/her Use Authorization as a medical radiation-generating equipment operator. Approval of Medical Operator status is granted by the Radiation Safety Officer based on completion of licensure and fulfillment of training specified in the facility Operating Procedures. The Radiation Safety Officer may approve persons who are clearly qualified.

9.2.5.1 MEDICAL OPERATOR TRAINING

The Faculty User must:

a) Submit the prospective operator's prior training and experience on Form RSO-02 to the Radiation Safety Officer.

b) Ensure the individual has a Radiographers or a General X-ray Machine Operators license.

c) Provide and document training to each new operator on the topics addressed in the Operating Procedures. The operator completion form may be used if the operator will likely receive a total effective dose equivalent of 100 mrem per year. Complete general radiation safety training provided by the Radiation Safety Officer.

d) Provide direct (observed) supervision for each operation until the Faculty User is confident that the prospective operator complies with the Operating Procedures and can work independently. The period of supervision depends on the prospective operator’s performance and previous experience with similar devices.

e) When training is complete, the Facility Coordinator must document and sign off before adding the individual to the Faculty User’s authorization. The individual can be added to a Use Authorization by a Faculty Operator by submitting a memorandum to the Radiation Safety Officer for approval/review by the Radiation Safety Officer.

9.2.5.2 MEDICAL OPERATOR RESPONSIBILITIES

a) Operate only radiation-generating equipment for which approval has been granted. Maintain licensure in accordance with OAC 3701-72. Notify the Faculty Coordinator if the operator’s license has expired or has been taken away for any reason.

b) Adhere to the safety rules and regulations as promulgated in this manual, facility Operating Procedures, and any communications from the Radiation Safety Committee.

c) Wear issued radiation dosimeters when radiation-generating equipment is operating. Return the dosimeters to the Radiation Safety Officer immediately when use is discontinued.

d) Operate radiation-generating equipment in such a way as to keep radiation exposures for all personnel, including the patient, As Low As Reasonably Achievable *(ALARA).*

e) Before operating any radiation-generating equipment, visually check and clear anyone from the exposure room (room where radiation-generating equipment is located) who may be unnecessarily exposed to radiation.

f) Ensure that radiation-generating equipment is secured against unauthorized use. Remove any keys or use lockout/tag out procedures to ensure the equipment is tamper-proof. Ensure all entry doors are locked.

g) Inform the Radiation Safety Officer and the Faculty User immediately of any safety related incident that has or could have resulted in personal injury, even if it occurs after normal working hours.

h) Inform the Facility Coordinator and Radiation Safety Officer if any certified components fail. Certified components must be replaced by certified components.

i) Report any malfunctions or unusual operating conditions to the responsible Faculty User and the Facility Coordinator.

9.2.6 STUDENT OPERATOR

There may be instances when a student will take a semester course with the opportunity to use radiation-generating equipment in the laboratory. Student users can be listed as Facility Operators but would generally be considered "training-under-observation" and thus will never become independent operators placed on a research Use Authorization without additional, in-depth tutelage or permission of the Radiation Safety Officer.

Student operators must complete the general radiation safety training, as well as machine-specific training.

Student Operators must follow the same guidelines as the Facility Operator, listed above.

9.3 EMERGENCY RESPONSE

Any unusual event that may injure an individual or damage the radiation-generating equipment or the facility must be handled immediately to prevent the situation from becoming worse. Some potential emergency situations include electrical shock, accidental radiation exposure, fire in the facility or elsewhere in the building, detection of fumes, unusual sounds, water leaks, and smoke.

Situations involving severe or life-threatening injuries can vary significantly. The outcome of an emergency depends largely on the actions taken by the persons present.

9.3.1 General guidance for emergency response

The following list of actions prescribes general guidance for emergency response.

a) Key to any reaction is for the responder to act calmly and rationally.

b) The operating procedures for each facility may address specific actions expected of operators in the event of an actual emergency.

c) The event should be recorded in detail in the Use Log or by memorandum to the Facility Coordinator and Radiation Safety Officer as soon as possible after the situation is under control.

9.3.2 Emergency procedures for Radiation-Generating Equipment (RGE)

a) Shut down the radiation-generating equipment.

b) If personal radiation exposure is suspected, avoid changing the operating parameters. This information may be necessary to reconstruct exposure conditions.

c) **IMMEDIATELY NOTIFY the Radiation Safety Officer, Facility Coordinator, and Faculty User.** The Facility Coordinator or Faculty User will immediately notify the Department Chair.

d) If injuries are suspected:

(1) Serious Injuries. The university procedures for injuries and illnesses are outlined in Wright Way Policy 13275. Immediate assistance for serious injuries should be sought. On the main campus call the Wright State Police Dispatch by dialing 2111 or 911, or use any emergency telephone located in the corridors throughout the campus. For off-campus laboratories, either use the medical facilities immediately available or call the local paramedics for assistance.

(2) Minor Injuries. Consult Wright Way Policy 13275.

e) **Ensure the unit cannot be used** until the problem is resolved by removing facility keys. Post a sign, "DO NOT USE" on the console, if circumstances permit. Only the Radiation Safety Officer can remove a “DO NOT USE” sign. Disconnect the system from the electrical power, if safely feasible.

9.4 THE ACQUISITION OF RADIATION-GENERATING EQUIPMENT (RGE)

The purchase or receipt of radiation generating equipment shall be coordinated with the Radiation Safety Officer during the initial planning stages to ensure that the facility is adequately shielded and the device can be properly registered with the Ohio Bureau of Radiation Protection as mandated by the Vice President of Research and Innovation or their designee.

Installed radiation-generating equipment may not be operated, other than for controlled, preliminary, installation tests, until all safety interlocks and warning devices are fully operational, administrative requirements have been met, and acceptance tests have been performed by the Radiation Safety Officer or other qualified person approved by the Radiation Safety Officer.

9.5 TRAINING REQUIREMENTS

Training requirements are listed under each type of user description. The operators of radiation-generating equipment require initial and annual refresher radiation safety training. Scanning electron microscopes and photoelectron spectrometers are **excluded** from these requirements and are given a document summarizing the hazards of use for equipment type. The Facility Coordinator or the Faculty User must be available during the review of the training topics and must initial the training sheet beside the Facility Operator’s name when the review is complete. The training roster must be kept in the user’s log easily accessible by the Radiation Safety Officer and the inspectors from the Ohio Department of Health. Obtain the training roster form by contacting the Radiation Safety Office.

9.5.1 TRAINING FOR COLLEGE ADMINISTATORS, COLLABORATORS, AND VISITORS

Bystanders and visitors (such as members of the Wright State University Administrative offices [i.e. Vice-Presidents, Deans, Department Chairs] students, maintenance or custodial personnel, and members of the general public) must receive instruction in accordance with OAC 3701:1-38-10(B). A Laboratory Hazard Instruction form or training implemented in the facility operating procedures provides acceptable criteria and documentation to fulfill this requirement.

9.5.2 TRAINING FOR PHOTOELECTRON SPECTOMETERS

Photoelectron spectrometers use electrons to image very small features. Ancillary to this imaging is the production of X-rays. These X-rays are fully shielded within the spectrometers housing. The X-ray housing has been checked

for radiation leakage and none has been observed. Operators and observers of photoelectron spectrometers should not receive radiation exposure in excess of natural background doses from this facility.

Facility Coordinators whose inventory includes a photoelectron spectrometer are required to use the radiation-generating equipment-specific form via the Radiation Safety Office for training purposes. The topics of the training are included on the back of the form. Training must also include machine-specific training. Facility Coordinators and Operators must sign off on the training form before the initial use of each specific unit. Please store the training form in the user logbook for each instrument for easy access to the Radiation Safety Officer and Ohio Department of Health inspectors.

Operators of photoelectron spectrometers are not required to complete the general radiation safety training offered by the Radiation Safety Officer.

9.6 EXPERIMENTAL RADIATION GENERATING EQUIPMENT USE AUTHORIZATIONS

9.6.1 APPLICATIONS FOR RADIATION GENERATING EQUIPMENT USE AUTHORIZATIONS

A Radiation Generating Equipment Use Authorization is a written form of communication between a Faculty User and the Radiation Safety Officer. The Use Authorization application briefly describes how the radiation-generating equipment will be used, with a commitment to follow the facility operating procedures, as well as any other safety measures that will be taken. The Application for Use of Radiation-Generating Equipment (Form RSO-03A) must be reviewed by the Facility Coordinator and Radiation Safety Officer and approved by Environmental Health and Safety ***prior to using*** the radiation-generating equipment. The Radiation Safety Officer may grant interim. The Radiation Generating Equipment Use Authorization application must show that anticipated radiation exposures will be consistent with ALARA.

Once approved, the Radiation-Generating Equipment Use Authorization will be valid for five years. Upon the date of the fifth year, the Use Authorization will expire and must be renewed in order to continue the project. The Use Authorization will be terminated *30 days* after the anniversary date of approval and the equipment will be locked out/tagged out by the Radiation Safety Officer or qualified Environmental Health and Safety personnel.

The Radiation Safety Officer will review the Radiation Generating Equipment Use Authorization, specifically consider the adequacy of facility shielding with the equipment to be used, operating and emergency procedures, and the training and experience of proposed operators. The submitted Radiation Generating Equipment Use Authorization for use of radiation-generating equipment will address the topics listed below. Consult with the Radiation Safety Officer if you have questions regarding the Radiation Generating Equipment Use Authorization application. All applications must be typed/printed/signed.

a) *list the personnel involved*, include a Form RSO-02 for operators who have previous training and experience. Ensure they have appropriate training or licensure as specified in the operating procedures.

b) *list all radiation-generating equipment* that will be used in the study, type(s) of radiation (e.g., x-ray, electrons) and energy, the exposure monitoring devices (e.g., TLD), area survey equipment (e.g., Geiger-Müller detector), and the location of the radiation-generating equipment.

c) *briefly describe the proposed use*. Address procedures (specify a commitment to follow the facility operating procedures or address special procedures that will be used), materials or subjects to be irradiated, and safety precautions. Also consider:

   (1) For clinical and research x-ray units for use with human subjects- approval from the Institutional Review Board is obtained?

   (2) Do you plan to use animals or biological agents?

   (3) Are any non-radiation concerns for safety evident (e.g., handling high voltages or hazardous chemicals)?

(4) Is there a potential for ozone or other hazardous gas production? Is the ventilation adequate?

9.6.2 CHANGES IN THE RADIATION GENERATING EQUIPMENT USE AUTHORIZATION

9.6.2.1.1 Minor Changes

a) An example of a minor change of a Radiation Generating Equipment Use Authorization is adding or deleting an operator. Minor changes require a memorandum from the Faculty User to the Radiation Safety Officer indicating the change and briefly explaining the reason. The Radiation Safety Officer will approve the change.

9.6.2.2 Significant Changes

a) Radiation Generating Equipment Use Authorization changes where the procedures or project scope differ significantly from the existing use Radiation Generating Equipment Use Authorizations approved by the Radiation Safety Officer (e.g., changes from previous operating conditions, shielding changes, change in facility design) require the submission an additional Radiation Generating Equipment Use Authorization application form (Form RSO-03A). The Radiation Safety Officer provide final approval.

9.6.3 SUSPENSION OF THE RADIATION GENERATING EQUIPMENT USE AUTHORIZATION

Facility Coordinators who are not currently using radiation-generating equipment, but may do so in the foreseeable future may place their Radiation Generating Equipment Use Authorization in suspension by informing the Radiation Safety Officer in writing. The Facility User must give ample (i.e., about two weeks) notice to the Radiation Safety Officer when radiation-generating equipment usage will be restarted. All equipment will be locked out/tagged out during the suspension period.

9.6.4 TERMINATION OF THE RADIATION GENERATING EQUIPMENT USE AUTHORIZATION

Radiation Generating Equipment Use Authorizations expired on the fifth-year date of approval by the Radiation Safety Officer and are terminated 30 days later.

Facility Coordinators and Faculty Users who plan to discontinue using the radiation-generating equipment or end their university affiliation must terminate their Radiation Generating Equipment Use Authorization by:

a) informing the Radiation Safety Officer of termination plans.

b) returning all facility keys to the Facility Coordinator, Department Chair, or Radiation Safety Officer.

c) returning the Radiation Safety Manual and dosimetry to Environmental Health and Safety.

9.7 PROTECTIVE MEASURES FROM EXPOSURE

9.7.1 TIME, DISTANCE, AND SHIELDING

Use of the principles of time, distance, and shielding can significantly reduce personal exposure to levels that are *as low as reasonably achievable* (ALARA). Practical applications include using lead aprons for fluoroscopy and standing clear of primary radiation beams and radiation areas.

a) *TIME*: Radiation exposure can be decreased by reducing the amount of time people spend working in radiation fields.

b) *DISTANCE*: X ray intensity decreases inversely with the square of the distance ($1/d^2$) when the source is small compared to the distance. For instance, if you double your distance from a radiation source, you reduce your exposure by (1/4) one-fourth. The radiation intensity decreases more slowly for large radiation-generating equipment or planar sources.

c) *SHIELDING*: Attenuating material placed in the radiation path can effectively reduce external dose. The thickness of shielding needed is determined by the type and energy of radiation, type of shielding material, distance from the source, time spent in the work area, and acceptable level of dose reduction. The adequacy of the shielding is evaluated by the Radiation Safety Officer and verified using a survey meter. The exposure rate to the user should be reduced to 1 mrem/hr or less for long procedures. The exposure rate in any unrestricted area must not exceed 2 mrem/hr. Dose to members of the public must be restricted to less than 100 mrem/year. In the interest of *ALARA* the exposure rate in any unrestricted area should be consistent with background. Information on the attenuating characteristics of shielding materials can be obtained from the Radiation Safety Officer.

Inform the Radiation Safety Officer if facility changes (e.g., structural changes, moving radiation-generating equipment, increasing operating voltage range, construction around the facility) are contemplated or in progress so that the potential impact on shielding can be evaluated.

9.7.2 GENERAL PRECAUTIONS WHEN USING RADIATION-GENERATING EQUIPMENT

a) Never expose fingers, hands, or any other body part to the primary beam. No person may be intentionally exposed to the primary beam, except a patient who has a physician's order or Institutional Review Board approval. This restriction applies to training, demonstrations, and any other non-medical diagnostic purpose.

b) Never disengage a safety interlock (except as described by an approved Use Authorization) or warning device or operate a unit if one of these systems malfunctions.

c) Use time, distance, and shielding to minimize your exposure.

d) Properly wear dosimetry, if issued, whenever the radiation-generating equipment may be energized.

e) Record radiation-generating equipment usage and maintenance in a facility logbook, according to operating procedures.

f) Never energize electrical equipment if the floor or equipment is wet or if high voltage wires are exposed.

g) Never operate equipment for which you have not been trained.

h) Never alter, repair, or perform maintenance on radiation-generating equipment component(s) without authorization and approval from the Facility Coordinator.

9.7.3 ADDITIONAL PRECAUTIONS FOR MEDICAL RADIATION-GENERATING EQUIPMENT

a) The operator must remain behind the control shield during exposures, when applicable. Persons needed to attend to the patient (e.g., parents) must stay behind the operator's control shield or at least 2 meters from the x-ray tube during the exposure.

b) Use mechanical restraints for difficult patients. If the patient must be held, use a parent (or adult relative) wearing a lead apron. Leaded gloves are required if the restraining person must place their hands near the primary beam. No person will routinely hold patients.

c) Operators must use the fastest screen / film combination. Cassettes without intensifying screens cannot be used.

d) The source-image distance cannot be less than 30 cm.

e) Grids must be installed and used properly.

f) Processing solutions must be made and films must be processed according to manufacturer's specifications. Do not use expired film.

9.8 LOCATIONS OF USE

Each location having radiation-generating equipment must be registered by Radiation Safety Officer with the Ohio Bureau of Radiation Protection. The operation of each radiation-generating equipment is contingent upon verification of the adequacy of shielding, interlocks, warning devices, ventilation equipment, and personnel protection equipment by the Radiation Safety Officer. Inform the Radiation Safety Officer well in advance should it become necessary or desirous to change the location or dispose of radiation-generating equipment, whether it is operational or not.

9.9 FACILITY OPERATING PROCEDURES

The Radiation Safety Manual does not address specific concerns for each unit of radiation-generating equipment. As an extension of the Radiation Safety Manual, *Operating Procedures* provide guidance to radiation-generating equipment operators on facility procedures and safety requirements. The Facility Coordinator promulgates the Operating procedures. The procedures should be reviewed periodically by the Radiation Safety Officer and Facility Coordinator for possible updating or changes. Operating procedures must be present in the facility and accessible to all approved operators.

Since each radiation-generating equipment facility has distinctly different levels of concern, the operating procedures must address safety items that are specific to the facility. Any special precautions to enhance safety (e.g., access control, emergency response, usage) should be clearly communicated. The procedures should contain the following information, as applicable or if augmented from the conditions of this manual:

a) a brief description of the facility design and purpose

b) any limits to operations

c) training requirements

d) responsible parties and responsibilities

e) security

f) use log

g) safety interlocks and warning devices

h) good safety practices

i) dosimetry requirements

j) radiation detectors available for use

k) general safety concerns (e.g., electrical, noxious gases, lifting)

l) maintenance, repairs, system alterations, lockout/tag-out procedures

m) emergency procedures

n) checklists for start-up, operation, shutdown, testing interlocks, and warning devices

9.10 USE LOG

A record of radiation-generating equipment usage must be maintained to document routine operations and unusual events. The presence of visitors, students, or trainees must be recorded. This record should be retained indefinitely.

a) Routine Entries. Routine entries (depending on the type of unit) may include date, operator, operating parameters (e.g., kVp, mA), duration of exposure, or any other relevant information.

b) Testing of Interlocks. Whenever system interlocks or warning devices are tested, the result of that test must be logged.

c) Maintenance or Repairs. A record of maintenance and repairs should also be maintained. If the unit is inoperable or unsafe to operate, the record should indicate the status and what measures were taken to prevent operation.

d) Unusual Events. Unusual events may include irregular sounds, presence of fumes, vapors, or smoke, malfunction of components, or suspected injury to an individual.

9.11 SAFETY DEVICES

9.11.1 ROUTINE TESTING

The proper function of safety interlocks, visible and audible warning devices, emergency interrupt devices, radiation level monitors and key-lock or security shutoff switches will be verified at least:

a) once each quarter when the device is not routinely operated; or

b) prior to use after maintenance, repairs, or alteration that may affect safety device operation; and

c) prior to each use.

A record of the verification, observations and description of any repairs found necessary will be entered in the facility's use log.

9.11.2 SAFETY DEVICE FAILURE

Any time a safety device fails to operate properly, all operations in the facility must be immediately terminated. Implement lockout/tag-out procedures (if applicable). Post a "DO NOT USE" sign on the console and make an entry in the Use Log regarding the failure. The Facility Coordinator must be notified. The Radiation Safety Officer must be notified if anyone has or may have received an unplanned radiation dose greater than the ALARA levels. Once the problem is corrected, the safety devices will be tested again and results logged. The Facility Coordinator is the only person who can remove the “DO NOT USE” sign when the safety devices are shown to be operational.

9.11.3 SAFETY DEVICE BY-PASS

No safety or warning device may be defeated or by-passed during routine operation. Jumpers, interlock plugs, or other devices that may defeat safety or warning systems will be conspicuously tagged and a notice of its installation posted (e.g., a "DO NOT USE" sign, implement the university lockout/tag-out procedures) at the control panel of the radiation generating equipment. An entry in the Use Log must be made stating which safety device(s) has been over-ridden and for what purpose. After service or repair has been completed, the safety and warning equipment will be tested to verify proper operation. A log entry will be made stating that the facility is fully operational and safety devices have been tested. Only the Facility Coordinator may remove a "DO NOT USE" sign.

9.12 MAINTENANCE AND REPAIRS

The Facility Coordinator must authorize all repairs, maintenance, and facility alterations. Any change that may affect personal safety or radiation exposure, facility design, or shielding must be submitted to the Radiation Safety Officer for evaluation and for approval.

Manufacturer representatives, contracted maintenance and repair specialists may only make maintenance and repairs, or persons approved by the Facility Coordinator who has the training and experience to make repairs safely. The Facility Coordinator must approve the procedures for maintenance and repairs. Implement "lockout/tag-out" procedures, if applicable. A "DO NOT USE" sign must be posted on the unit's console and a log entry made to record the respective repairs. When the unit is operational and the safety interlocks are tested, a log entry is made. Only the Facility Coordinator may remove the "DO NOT USE" sign when the facility is fully operational.

9.13 SECURITY

Radiation generating equipment (RGE) will be secured against tampering and unauthorized operation. The controls of the device will be inaccessible, locked, disconnected or otherwise disabled, or positively secured when not under the physical supervision of an approved operator.

In special circumstances, equipment may be operated while unattended; so long as positive security against unauthorized entrance to radiation areas and the operating controls are maintained. Conditions for unattended operation should be clearly stated in the operating manual. Two requirements for unattended operation are:

1. the entryway must be locked and safeguarded against unauthorized entry and;
2. a notice must be posted at the entryway informing departmental and emergency personnel of necessary precautions and actions in case of an emergency.

9.14 POSTING / LABELING WARNING SIGNS

Warning signs and labels heighten the awareness of persons who may enter the lab and alert them of possible or imminent dangerous conditions. They provide a constant reminder for operators, custodians, and maintenance personnel to exercise caution and responsible action.

9.14.1 POSTING AT LAB ENTRYWAYS

a) Radiation Area. A warning sign bearing the radiation symbol and "Caution Radiation Area" will be conspicuously posted at the entrance to an accessible area where a person could receive 5 millirem (0.05 mSv) in one hour at 30 cm from the radiation source or its shielding.

Figure 13. Example of Radiation Area Sign

b) High Radiation Area. A warning sign bearing the radiation symbol and "Caution High Radiation Area" will be conspicuously posted at the entrance to any accessible area where a person could receive 100 millirem (1mSv) in one hour at 30 cm from the radiation source or its shielding.

Figure 14. Example of High Radiation Area Sign

c) Notice to Employees. Ohio Department of Health form 4786.32 "*Notice to Employees*", must be visibly posted in or near laboratories where radiation-generating equipment is located.

9.14.2 Damaged Signs

Damaged Signs. The Facility Coordinator will notify the Radiation Safety Officer for a replacement if any posted form is found defaced, altered, or removed.

9.14.3 WARNING ON CONTROL PANEL

The control panel of a radiation generating equipment will be labeled with the notice, "Caution: This machine produces radiation when energized." or similar words appropriate for the radiation-generating equipment.

9.15 VENTILATION

Ventilation of air from the operation of high-energy particle accelerators may yield noxious gases, such as ozone and nitrous oxide. Significant accumulation of noxious gases can occur in poorly ventilated high radiation areas. Radiation in closed containment vessels can generate especially high concentrations of noxious gases, which must be vented to the atmosphere outside the building. Radiation interaction with some gases, such as SF6, can increase their toxicity. Irradiation of some solids or liquids may produce noxious decomposition products. Experimental Use Authorizations must address such reactions, if applicable, so that the Department of Environmental Health and Safety can evaluate the proposal for appropriate controls. The Facility Coordinator will develop procedures, which may include restrictions to operations, based on recommendations by EHS staff for compliance with air quality requirements.

9.16 EXPOSURE RATE MONITORING

Facilities that have portable survey meters for area monitoring should use them periodically to verify the radiation exposure levels in occupied areas are consistent with ALARA. More frequent surveys may be required by facility procedures. If an operator questions whether radiation production has ceased, a survey of potential exposure must be made prior to entry.

a) Meter Appropriation. Facility Coordinators are encouraged to acquire their own instruments for routine use from research or departmental funds. Survey meters are available for a wide variety of uses. The Radiation Safety Officer can assist researchers with selection of the appropriate instrument for the intended purpose. For special applications, survey meters that are satisfactory for most purposes are available on loan from Environmental Health and Safety.

b) Calibration / Repair. Survey meters must be calibrated annually or biennially, in accordance with Ohio Department of Health rules. Environmental Health and Safety ensures this service is completed. The cost of repair or replacement of instruments damaged through misuse or careless handling is the responsibility of the laboratory. The calibration should be verified after significant repairs are made or the detector's response to radiation is questioned.

c) Operational Checks. Prior to use, the survey meter should be checked to ensure it is operating properly. Check the:

   (1) *Battery condition*. If low, change the batteries. Consult the Radiation Safety Officer if you have questions. Changing the battery does not require calibration.

   (2) *Calibration label*. The instrument must be calibrated within 1 year (meters used with some radiation generating equipment and all industrial radiation generating equipment require calibrating every 6 months).

   (3) *Meter response*. Ensure the meter responds properly to the source on the side, if applicable.

d) Monitoring Procedures. Use the open window part of the probe for maximum detectability. Move the detector slowly. Using the audio (if available) facilitates detection at background levels. Sporadic counts may be due to cable movement. Areas where this occurs should be monitored again with the detector movement suspended until the reading can be made. Log results that are distinguishable from background. If results exceed 2 mR/hr, notify the Facility Coordinator and Radiation Safety Officer.

9.17 FACILITY EVALUATIONS

The Radiation Safety Officer surveys each facility containing radiation-producing equipment soon after installation to ensure compliance with Ohio Bureau of Radiation Protection rules. The survey will evaluate administrative and engineering controls, such as interlocks, warning devices, operating and emergency procedures, security, and shielding. Radiation exposure levels in areas that may be occupied during operation are also recorded.

Each facility will be re-evaluated either annually or as required.

Surveys will also be conducted when significant modifications are made to the facility or near the facility that may affect the integrity of shielding. The Facility Coordinator must notify the Radiation Safety Officer when such changes are expected or suspected.

The survey results are reported to the Facility Coordinator who will ensure corrective actions are made. If the facility is considered unsafe to operate, the Facility Coordinator will ensure that the facility is closed and positive measures are taken to prevent operation until repairs rectify the problem.

The Ohio Bureau of Environmental Health and Radiation Protection (BEHRP) will inspect each operational unit periodically. For most radiation-generating equipment this period is every three years. Invoices for this service are forwarded to the respective department for payment. Timely remittance is encouraged. If the invoice is not paid within 90 days of the invoice date, the fee will increase.

9.18 DISPOSAL OF RADIATION-GENERATING EQUIPMENT (RGE)

The Facility Coordinator must notify the Department of Environmental Health and Safety, including the Radiation Safety Officer, whenever radiation-generating equipment is planned for disposal or permanently disabled so that proper administrative procedures may be followed. Radiation-generating equipment may be disposed by transferring the unit to another facility by sale or donation or the unit may be scrapped as waste.

The Radiation Safety Officer must notify the Ohio Bureau of Environmental Health and Radiation Protection (BEHRP) of the disposition of the unit and the state registration will need amended. If the unit is transferred to an Ohio facility, the Radiation Safety Officer should inform the new owner of the need to register the device. If the unit is disposed as scrap, the x-ray tube(s) must be de-activated and any hazardous chemicals or materials treated or removed prior to disposal.

10 RECORD RETENTION

Wright State shall maintain a copy of its license, license conditions, documents incorporated by reference, and amendments to each of these items until superseded by new documents approved by ODH, or until ODH terminates the license[112]. Copies of the license are available from the Department of Environmental Health and Safety.

(B) Each licensee shall maintain records showing the receipts and transfers of all sealed sources and all devices using depleted uranium for shielding and retain each record for three years after it is made. These records must include the date, the name of the individual making the record, radionuclide, number of becquerels (curies) or mass (for depleted uranium), and manufacturer, model, and serial number of each sealed source and/or device, as appropriate.

(C) Each licensee shall maintain records of the calibrations of its radiation survey instruments that are required under rule 3701:1-48-08 of the Administrative Code and retain each record for three years after it is made.

(D) Each licensee shall maintain records of leak test results for sealed sources and also for devices containing depleted uranium. The results must be stated in units of becquerels (microcuries). The licensee shall retain each record for three years after it is made or until the source in storage is removed from storage.

(E) Each licensee shall maintain records of the quarterly inventory of sealed sources and of devices containing depleted uranium as required by rule 3701:1-48-10 of the Administrative Code and retain each record for three years after it is made. The record must include the date of the inventory, name of the individual conducting the inventory, radionuclide, number of becquerels(curies) or mass (for depleted uranium) in each device, location of sealed source and/or devices, and manufacturer, model, and serial number of each sealed source and/or device, as appropriate.

(F)

(1) Each licensee shall maintain utilization logs showing for each sealed source the following information:

(a) A description, including the make, model, and serial number of the radiographic exposure device or transport or storage container in which the sealed source is located;

[112] https://codes.ohio.gov/oac/3701:1-48-23

(b) The identity and signature of the radiographer to whom assigned; and

(c) The plant or site where used and dates of use, including the dates removed and returned to storage.

(2) The licensee shall retain the logs required by paragraph (F)(1) of this rule for three years after the log is made.

(G) Each licensee shall maintain records specified in rule 3701:1-48-11 of the Administrative Code of equipment problems found in daily checks and quarterly inspections of radiographic exposure devices, transport and storage containers, associated equipment, source changers, and survey instruments; and retain each record for three years after it is made. The record must include the date of check or inspection, name of inspector, equipment involved, any problems found, and what repair and/or maintenance, if any, was done.

(H) Each licensee shall maintain records of alarm system and entrance control device tests required under rule 3701:1-48-12 of the Administrative Code and retain each record for three years after it is made.

(I) Each licensee shall maintain the following records of training and certification for three years after the record is made:

(1) Records of training of each radiographer and each radiographer's assistant. The record must include radiographer certification documents and verification of certification status, copies of written tests, dates of oral and practical examinations, and names of individuals conducting and receiving the oral and practical examinations; and

(2) Records of annual refresher safety training and semi-annual inspections of job performance for each radiographer and each radiographer's assistant. The records must list the topics discussed during the refresher safety training, the dates the annual refresher safety training was conducted, and names of the instructors and attendees. For inspections of job performance, the records must also include a list showing the items checked and any items of noncompliance observed by the radiation safety officer for industrial radiography.

(J) Each licensee shall maintain a copy of current operating and emergency procedures until the director terminates the license. Superseded material must be retained for three years after the change is made.

(K) Each licensee shall maintain the following exposure records specified in rule 3701:1-48-19 of the Administrative Code:

(1) Direct reading dosimeter readings and yearly operability checks required by paragraphs (B) and (C) of rule 3701:1-48-19 of the Administrative Code for three years after the record is made.

(2) Records of alarm rate meter calibrations for three years after the record is made.

(3) Personnel dosimeter results received from an accredited national voluntary laboratory accreditation program (NVLAP) processor until the director terminates the license.

(4) Records of estimates of exposures as a result of off-scale personal direct reading dosimeters, or lost, or damaged personnel dosimeters until the director terminates the license.

(L) Each licensee shall maintain a record of each exposure device survey conducted before the device is placed in storage as specified in paragraph (C) of rule 3701:1-48-20 of the Administrative Code, if that survey is the last one performed in the workday. Each record must be maintained for three years after it is made.

(M) Each record required by this part must be legible throughout the specified retention period. The record may be the original or a reproduced copy or a microform provided that the copy or microform is authenticated by authorized personnel and that the microform is capable of reproducing a clear copy throughout the required retention period. The record may also be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records, such as letters, drawings, and specifications, must include

all pertinent information, such as stamps, initials, and signatures. The licensee shall maintain adequate safeguards against tampering with and loss of records.

(N)

(1) Each licensee shall maintain copies of records required by this and other chapters at the location specified in paragraph (K) of rule 3701:1-48-04 of the Administrative Code.

(2) Each licensee shall also maintain copies of the following documents and records sufficient to demonstrate compliance at each applicable field station and each temporary job site:

(a) The license authorizing the use of licensed material;

(b) A copy of Chapters 3701:1-38 and 3701:1-48 of the Administrative Code;

(c) Utilization records for each radiographic exposure device dispatched from that location as required by paragraph (F) of this rule;

(d) Records of equipment problems identified in daily checks of equipment as required by paragraph (G) of this rule;

(e) Records of alarm system and entrance control checks required by paragraph (H) of this rule, if applicable;

(f) Records of direct reading dosimeters such as pocket dosimeter and/or electronic personal dosimeters readings as required by paragraph (K) of this rule;

(g) Operating and emergency procedures required by paragraph (J) of this rule;

(h) Evidence of the latest calibration of the radiation survey instruments in use at the site, as required by paragraph (C) of this rule;

(i) Evidence of the latest calibrations of alarm rate meters and operability checks of pocket dosimeters and/or electronic personal dosimeters as required by paragraph (K) of this rule;

(j) Latest survey records required by paragraph (L) of this rule;

(k) The shipping papers for the transportation of radioactive materials required by rule 3701:1-50-05 of the Administrative Code; and

(l) When operating under reciprocity, a copy of the agreement state or United States nuclear regulatory commission license authorizing the use of licensed materials.

Document ID	Document or Record	Reference	File Location	Retention
	Declared Pregnant Worker			
	Receipt of radioactive material			For as long as the material is possessed and for 3 years following the transfer or disposal of the material[113]

[113] NUREG 1556 Volume 7, Rev.1, Table 8-4 Record Maintenance, 2017.

	Inventory of radioactive material		For 3 years from the date of the inventory in accordance with the license condition[114]
	Transfer of radioactive material		For 3 years after each transfer unless a specific requirement dictates otherwise[115]
	Disposal of radioactive material		Until ODH terminates the license[116]
	Decommissioning		Until the site is release for unrestricted use[117]
	Radiation Safety Manual		
	OAC 3701:1-38		
	OAC 3701:1-66		
	OAC 3701:1-68		
	ODH License	RAD 09-03-N-4	https://codes.ohio.gov/oac/3701:1-48-23 Until superseded by new documents or ODH terminates license.
	ODH Registrations		
	Dosimetry Issuance Card		
	Landauer Invoices		
	Landauer Dosimetry Records		
	Landauer Dosimetry Annual Reports		
	Lost Dosimetry Form		
	Annual dose reports		
	Dose estimate reports		
	RSO-01 Blank Form		
	RSO-01 Completed Forms		
	EHS Radioactive Material (RAM) Initial Training		
	EHS Radioactive Material (RAM) Refresher Training		
	RSO-07 Visitor User Application		
	Authorized Use Correspondence		
	Purchasing Approval		
	Package Receipt Form		
	Radioactive Material Tape		
	Radioactive Material Labels		

[114] NUREG 1556 Volume 7, Rev.1, Table 8-4 Record Maintenance, 2017.
[115] NUREG 1556 Volume 7, Rev.1, Table 8-4 Record Maintenance, 2017.
[116] NUREG 1556 Volume 7, Rev.1, Table 8-4 Record Maintenance, 2017.
[117] NUREG 1556, Table 8-4 Record Maintenance, 2017.

	Radioactive Material Posting (Signs)		
	Survey Meter Calibration Data		
	Package Receipt Liquid Scintillation Counter Printout (Report)		
	LSC Calibration Records		
	Use Location List (2 year review)		
	Inventory Cards (Blank)		
	Inventory Cards In Use		
	Central Inventory Records		
	Contamination Surveys – Monthly	Radioactive Materials – Surveys for Contamination	RAD 9-7-3
	Contamination Surveys – Weekly		
	Contamination Surveys – Daily		
	Contamination Surveys – Procedure		
	Contamination Surveys - Immediate		
	Liquid Scintillation Counter Records		
	Gamma Counter Records		
	Lab Swipe Records		
	Unrestricted Use Reviews		
	Survey Meter Assignments		
	Survey Meter Calibration Records		
	Equipment Release Forms		
	Location Use Release Reports		
	Spills or Emergency Response Reports		
	Bioassay Reports		
	Iodination Requests		
	Sealed Source Inventory		
	Sealed Source Leak Tests		
	Sealed Source Records		

	Waste Inventory Cards
	Waste Forms
	Waste Decay in Storage
	Waste LLWR
RSO-03A	RSO-03A
RSO-01	Qualifications of RAM User
RSO-02	Qualifications of RGE User
	EHS RGE Initial Training
	EHS RGE Refresher Training
	RGE Use Log Forms
	RGE Postings
RSO-XXX	RGE Audit Forms
RSO-XXX	Lost Dosimetry Report Form

11 METRICS

Any metrics or key performance indicators (KPIs) associated with the Radiation Safety Program are established and tracked within the Wright State Environmental Health and Safety Metrics Program.

Metric	Data Collected
Dosimetry Issued in Calendar Year	Whole body dosimeters Finger rings Pocket dosimeters Posted dosimetry
Dosimetry Personnel Served in Calendar Year	Adult user`` Declared pregnant worker Minors High radiation area
Lost Dosimetry	Lost dosimetry record
Annual Dose Reports	Count of annual dose reports
Dose History Requests	Count of dose history requests
Dose History Estimates	Count of dose history estimates
Users of radioactive material	Authorized users Individual users Visitors Supervised users Non-worker Completed training
Radioactive Material Use Authorizations (RSO-03)	Count of RAM Use Authorizations Count of AU per Use Authorizations Count of Individual Users per Use Authorizations Count of Use Areas Count of Isotopes Quantity/Activity Use Limit Count of New RSO-03 Count of Amended RSO-03

	Count of Suspended RSO-03 Count of Terminated RSO-03
Package Receipts	Count of package receipts
Purchasing Notifications	Proportion of notifications vs actual received
Package approvals	Count of approvals
Radioactive Material Inventory	Isotope AU Use Location Storage Location
Transportation or Shipment of Radioactive Material	Count of Manifest
Postings	Count of radioactive room postings Percent compliant compared to AU locations
Contamination Surveys	Monthly Weekly End of Day After procedure Immediately
Liquid Scintillation Swipes	Count of use areas Sum of swipes analyzed
Gamma Swipes	Count of use areas Sum of swipes analyzed
Action Levels	Percent compliant
Survey Meters	Count of available meters Count of calibrated meters Count of meters assigned Cost for calibration services
Equipment Releases	Count of equipment released
Use Locations Releases	Count of use locations released
Spills or Emergency Response	Count of responses
Bioassays	Count of bioassays
Iodination Procedures	Count of iodination procedures
Sealed Sources	Count of 6-month leak tests Count of 3-month leak tests Count of leak tests for damaged sources Count of leak tests for sources in storage Count of sealed sources in central inventory by type, location, AU
Animal Use	Count of radioactive material used in animals
Radioactive Material Waste	Number of waste materials collected by EHS Solid waste Liquid waste Decay-in-storage Sewer discharge Low-level radioactive waste Animal waste Mixed waste Infectious waste
Users of radiation generating equipment	Facility coordinator Individual user Visitor user Supervised user

	Non-user Medical operator Student operator
Radiation generating equipment use authorizations (RSO-03A)	Count of RGE Use Authorizations Count of Facility coordinator per Use Authorizations Count of Individual Users per Use Authorizations Count of Use Areas Count of RGE Count of New RSO-03A Count of Amended RSO-03A Count of Suspended RSO-03A Count of Terminated RSO-03A
RGE Use Locations	Count of use locations
Requests for maintenance or repair of RGE	Count of maintenance requests
Security	Count of security reviews
Posting	Count of RGE postings Percent compliant compared to use locations
Exposure rate monitoring	Count of monitoring reviews
Annual facility evaluations	Count of facility evaluations Count of corrective actions
RGE disposal or transfer	Count of RGE disposal or transfer

12 APPENDICES

12.1 ODH License for Radioactive Material

Amendment No. *15*

OHIO DEPARTMENT OF HEALTH

LICENSE FOR RADIOACTIVE MATERIAL

Pursuant to Chapter 3718 of the Ohio Revised Code, and in reliance on statements and representations made by the licensee, a license is hereby issued authorizing the licensee named herein to receive, acquire, possess, and transfer radioactive material as designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the applications of Chapter 3748 of the Ohio Revised Code and all applicable rules promulgated thereunder. This license is subject to all applicable rules, regulations and orders of the Ohio Department of Health now or hereinafter in effect and to any conditions specified below.

LICENSEE	LICENSE NUMBER
1. Wright State University	3. 0362050021
	EXPIRATION DATE
2. 3640 Colonel Glenn Highway Dayton, Ohio 45435	4. February 1, 2022
	FILE NUMBER – ID NUMBER
	5. 50[070-*15519*]

6.	RADIOACTIVE MATERIAL	7.	CHEMICAL AND/OR PHYSICAL FORM	8.	MAXIMUM QUANTITY THAT LICENSEE MAY POSSESS AT ANY ONE TIME UNDER THIS LICENSE
A.	Hydrogen-3	A.	Any	A.	*Total possession not to exceed 4.55 GBq (120 mCi).*
B.	Carbon-14	B.	Any	B.	*Total possession not to exceed 1.85 GBq (50 mCi).*
C.	Phosphorus-32	C.	Any	C.	*Total possession not to exceed 3.59 GBq (70 mCi).*
D.	Phosphorus-33	D.	Any	D.	*Total possession not to exceed 259 MBq (7 mCi).*
E.	Sulfur-35	E.	Any	E.	*Total possession not to exceed 1.48 GBq (40 mCi).*
F.	Iodine-125	F.	*IRA kits*	F.	*Total possession not to exceed 185 MBq (5 mCi).*
G.	*Nickle-63*	G.	*Foil source*	G.	*Total possession not to exceed 12.21 GBq (325 mCi).*
H.	*Polonium-210*	H.	*Sealed Sources*	H.	*Total possession not to exceed 29.6 MBq (0.8 mCi).*
I.	*Iodine-129*	I.	*Sealed - Rod Sources*	I.	*Total possession not to exceed 18.5 MBq (0.5 mCi).*
J.	*Cesium-137*	J.	*Sealed Sources*	J.	*Total possession not to exceed 18.5 MBq (0.5 mCi).*
K.	Barium-133	K.	Sealed Source	K.	370 MBq (10 mCi).
L.	Radium-226	L.	Sealed Sources	L.	370 kBq (10 μCi) per source; total possession not to exceed 740 kBq (20 μCi).

9. Authorized Use

A. thru F.	For research and development as defined in OAC 3701:1-38-01, to include animal studies.
G.	*For use in a Hewlett Packard model 6890 or Agilent model 7890A gas chromatograph.*
H.	*For use in an Amstat Industries model 2150/6 or equivalent antistatic device for random interaction and/or research.*
I.	*In storage but may be used for required instrument verification.*
J. thru L.	Check calibration and reference sources.

CONDITIONS

10. Licensed material may only be used or stored at the licensee's facilities located at:
    - A. *Biological Sciences I rooms: 022 and 215;*
    - B. *Biological Sciences II rooms: 141, 156 and 158;*
    - C. *Brehm Laboratory room: 259;*
    - D. *Diggs Laboratory rooms: 035, 195, 196C, 335, 365, and 221;*
    - E. *Fawcett Hall room: 500;*
    - F. *Health Sciences Building room: 238;*
    - G. *Math and Microbiology Building rooms: 006, 012 and 012A;*
    - H. *NEC Building rooms: 136 and 461;*
    - I. *Oelman Hall room: 201; and*
    - J. *Waste Facility.*

11. The Radiation Safety Officer for this license is: *Marjorie M. Markgraber, Ph.D.*

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OHIO DEPARTMENT OF HEALTH LICENSE FOR RADIOACTIVE MATERIALS SUPPLEMENTARY SHEET	Page 2 of 2
	License Number: **03620580021**
	File Number – ID Number: **501070-*15519***
	Amendment No. ***15***

12. ***Licensed material shall only be used by, or under the supervision of, the individuals listed below:***

	Authorized User		***Radioactive Materials***
A.	***Abinash Agrawal, Ph.D.***	A.	***Ni-63 and Ba-133***
B.	***David Goldstein, Ph.D.***	B.	***H-3, C-14 and Ba-133***
C.	***Michael Hennessy, Ph.D.***	C.	***I-125 RIA kits***
D.	***Steven Higgins, Ph.D.***	D.	***Ni-63 and Po-210***
E.	***Weiwen Long, Ph.D.***	E.	***P-32***
F.	***Julie Skipper, Ph.D.***	F.	***Cs-137***
G.	***John Paietta, Ph.D.***	G.	***P-32 and S-35***
H.	***Yvonne Vadeboncoeur, Ph.D.***	H.	***H-3, C-14, P-32 and P-33***
I.	***Thomas Brown, Ph.D.***	I.	***C-14***
J.	***Khalid Elased, Ph.D.***	J.	***H-3***
K.	***Madhavi Kadakia, Ph.D.***	K.	***C-14, P-32 and Ba-133***
L.	***Michael Leffak, Ph.D.***	L.	***H-3, C-14 and P-32***
M.	***Yong-jie Xu, MD, Ph.D.***	M.	***H-3 and P-32***

13. **All sealed sources that are used or obtained shall have been evaluated or approved under the provisions of OAC 3701:1-46-49, or equivalent NRC or Agreement State regulations.**
14. **Sealed sources shall be tested for leakage and/or contamination in accordance with OAC 3701:1-38-24.**
15. **The licensee shall conduct a physical inventory every six (6) months to account for all *to account for all licensed material* received and possessed under the license. Records of inventories shall be maintained for three (3) years from the date of the inventory and shall include the quantities and kinds of *licensed* material, *material location*, and the date of the inventory.**
16. **In lieu of the conventional format specified in OAC 3701:1-38-18, the licensee is authorized to label detector cells, containing licensed material and used in gas chromatography devices, with radiation caution symbols which have been conspicuously etched or stamped, without a color requirement.**
17. **Sealed sources or detector cells containing licensed material shall not be opened or sources removed from source holders by the licensee.**
18. **Experimental animals or the products from experimental animals that have been administered licensed materials shall not be used for human consumption.**
19. **This license does not authorize commercial distribution of licensed material**
20. **Licensed material shall not be used in or on human beings or in products distributed to the public.**
21. **The licensee is authorized to hold radioactive material for decay-in-storage in accordance with OAC 3701:1-38-19(E).**
22. **Posting of radioactive waste held for decay in storage must be in accordance with OAC 3701:1-38-18(C)(1).**
23. **The licensee is authorized to transport licensed material only in accordance with the provisions of OAC 3701:1-50.**
24. ***In addition to the possession limits in item 8, the licensee shall further restrict the possession of sealed source licensed materials to quantities below the minimum limit specified in OAC 3701:1-40-17 for establishing decommissioning financial assurance.***
25. **Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents, including any enclosures, listed below. The Ohio Department of Health's statutes, rules, and orders shall govern unless statements, representations, and procedures in the licensee's application and correspondence are more restrictive than the regulations.**
    A. **Renewal application dated August 31, 2016. Amendment 12 renews license number 01110580000 in its entirety.**
    B. ***Amendment 13 (Not issued).***
    C. ***Email correspondence dated August 14, 2018 (Amendment 14).***
    D. ***Correspondence dated December 10, 2019 and email correspondence dated February 28, May 5, 8, 14 and 19, June 28 and July 10, 2020 (Amendment 15).***

For the Ohio Department of Health

DATE: July 24, 2020 **BY:** W. Gene Phillips, RS

W. Gene Phillips, MBA, RS
Chief, Bureau of Environmental Health and Radiation Protection
on behalf of the Director of Health