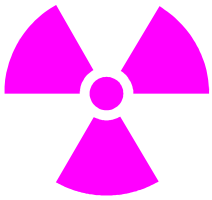
RADIOACTIVE MATERIAL SAFETY MANUAL



ISSUED BY

WESTERN KENTUCKY UNIVERSITY
RADIATION SAFETY COMMITTEE and
DEPARTMENT OF ENVIRONMENTAL HEALTH & SAFETY

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Appendices

Section 1. Acronyms and Abbreviations Used in This Manual

ALARA:	As Low As Reasonably Achievable
AU:	Authorized User
Bq:	becquerel
C:	coulomb
Cabinet:	Kentucky Cabinet for Health and Family Services
CEDE:	committed effective dose equivalent
CFR:	Code of Federal Regulations
CHFS:	Kentucky Cabinet for Health and Family Services
Ci:	curie
μCi:	microcurie
mCi:	millicurie
cm^2:	square centimeter
DDE:	deep dose equivalent
DOE:	United States Department of Energy
DOT:	United States Department of Transportation
dps:	disintegrations per second
dpm:	disintegrations per minute
DU:	depleted uranium
EH&S:	WKU Department of Environmental Health & Safety
gal:	gallon
GM or G-M	Geiger-Mueller
Gy:	gray
hr:	hour
J:	Joule
KAR:	Kentucky Administrative Regulations
kg:	kilogram
LDE:	lens dose equivalent
LD50:	lethal dose, 50 %
LET:	linear energy transfer
LLRW:	Low Level Radioactive Waste

LLRMW:	Low Level Radioactive Mixed Waste
LSA:	liquid scintillation analyzer
MeV:	mega electron volt
ml:	milliliter
mR:	milliroentgens
mrem:	millirem
NORM:	Naturally Occurring Radioactive Material
NRC:	United States Nuclear Regulatory Commission
OSL:	optically stimulated luminescence
PPE:	personal protective equipment
Q:	quality factor
R:	roentgen
rad:	radiation absorbed dose
RHB:	Kentucky Radiation Health Branch
RMSM:	Radioactive Material Safety Manual
RSC:	Radiation Safety Committee
RSO:	Radiation Safety Officer
RBE:	relative biological equivalent
rem:	roentgen equivalent man
RWP:	Radiation Work Permit
SDE:	shallow dose equivalent
SI:	standard international
SU:	Supervised User
Sv:	sievert
TEDE:	total effective dose equivalent
TLD:	thermoluminescent dosimeter
$t_{1/2}$:	half life
WKU:	Western Kentucky University
XRF:	x-ray fluorescence

Section 2. Definitions

Absorbed Dose – The amount of ionizing radiation energy absorbed in matter, including human tissue. The units of absorbed dose are the rad and the gray (Gy). 1 rad = 0.01 Gy

Activation – The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear radiation.

Activity – The rate of transformation (or "disintegration" or "decay") of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq). 1 Ci = 3.7×10^{10} Bq

Acute Exposure – The absorption of a relatively large amount of radiation (or intake of radioactive material) over a short period of time.

Acute Health Effects – Prompt radiation effects (those that would be observable within a short period of time) for which the severity of the effect varies with the dose, and for which a practical threshold exists.

Acute Radiation Syndrome – The complex of symptoms characterizing the disease known as radiation injury, resulting form excessive exposure of the whole body (or large part) to ionizing radiation. The earliest of these symptoms are nausea, fatigue, vomiting, and diarrhea, which may be followed by loss of hair (epilation) hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been relatively large, death may occur within two to four weeks. Those who survive six weeks after the receipt of a single large dose of radiation may generally be expected to recover.

Agreement State – Any State with which the U.S. Nuclear Regulatory Commission or the U. S. Atomic Energy Commission has entered into an effective agreement under subsection 274b. of the Atomic Energy Act of 1954, as amended (73 Stat. 689).

ALARA – (Acronym for "as low as is reasonably achievable")--Making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the activity is undertaken, taking into account the state of technology, the economics of improvements in relation to 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 radioactive materials in the public interest.

Alpha Particle – A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2.

Annual Limit on Intake (ALI) – 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 5 rem or a committed dose equivalent of 50 rem to any individual organ or tissue.

Background radiation – Radiation that occurs naturally in the environment. Background radiation consists of cosmic radiation from outer space, radiation from the radioactive elements in rocks and soil, and radiation from radon and its decay products in the air we breathe.

Becquerel – A unit, in the International System of Units (SI), of measurement of radioactivity equal to one disintegration per second.

Beta Particle – A negatively charged particle that is emitted by certain radioactive atoms. A beta particle is identical to the electron.

Bioassay – 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 (in vitro) from the human body.

Biological half-life – The time required for a biological system, such as that of a human, to eliminate by natural processes half of the amount of a substance (such as a radioactive material) that has entered it.

Chronic dose – The absorption of radiation (or intake of radioactive materials over a long period of time, i.e., over a lifetime).

Class (or Lung Class or Inhalation Class) – 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 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

Committed dose equivalent ($H_{T,50}$) – 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 (50) year period following the intake.

Committed effective dose equivalent ($H_{E,50}$) – The sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ($H_{E,50} = \text{å}W_T H_{T,50}$).

Contamination – the deposition of unwanted radioactive material on the surfaces of structures, areas, objects or personnel.

Cosmic radiation – Penetrating ionizing radiation, both particulate and electromagnetic, originating in space. Secondary cosmic rays, formed by interactions in the earth's atmosphere, account for about 45 to 50 millirem annually.

Cumulative dose – The total dose resulting from repeated exposures of ionizing radiation to the same region, or to the whole body, over a period of time.

Curie (CI) – The basic unit of activity. A quantity of a radionuclide that undergoes an average disintegration rate of 37 billion disintegrations per second. One curie is the approximate activity of 1 gram of radium. Named for Marie and Pierre Curie, who discovered radium in 1898.

Daughter product – The nuclide produced by the decay of a radioactive nuclide

Declared pregnant woman – A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Deep dose equivalent – The dose equivalent estimated for a tissue depth of 1 cm. The deep-dose equivalent applies to external whole-body exposure and is intended to represent the upper limit to the dose received by the major organs and tissues of the body other than skin and lens of the eye.

Detector – A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation detection instrument.

Dose (or radiation dose) – A generic term that means absorbed dose, equivalent dose, effective dose, committed equivalent dose, committed effective dose, or total effective dose, as defined elsewhere in this section.

Dose equivalent (H_T)" means the product of the absorbed dose in tissue, the quality factor, and other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and sievert (Sv).

Dose rate – The radiation dose delivered per unit time. Measured, for example, in rem or Sv per hour.

Dosimeter – A portable instrument for measuring and recording the total accumulated exposure to ionizing radiation.

Effective dose equivalent (H_E) – The sum of the products of the dose equivalent to the organ or tissue (H_T) and the weighting factors (W_T) applicable to each of the body organs or tissues that are irradiated ($H_E = W_T H_T$).

Effective half-life – The time required for the amount of a radioactive element deposited in a living organism to be diminished 50 percent as a result of radioactive decay and biological elimination.

Electromagnetic radiation – Energy being propagated by a traveling wave motion resulting from changing electric or magnetic fields. Familiar electromagnetic radiations range from x-rays and gamma rays of short wavelength, through the ultraviolet, visible and infrared regions, to radar, radio waves of relatively long wavelength. The ionizing electromagnetic radiations are gamma rays and x-rays.

Exposure – A measure of the ionization produced in air by x- or gamma radiation; the sum of electric charges on all ions of one sign produced in air when all electrons liberated by photons in a volume of air are completely stopped in air, divided by the mass of the air in the volume; unit of exposure in air is the roentgen. Also, being exposed to ionizing radiation or to radioactive material.

External Dose – That portion of the dose equivalent received from radiation sources outside the body.

Gamma Rays – Gamma radiation is high-energy, short-wavelength electromagnetic radiation emitted from the nucleus. A gamma ray is a discrete packet of electromagnetic energy. Gamma rays are very penetrating and are best stopped or shielded against by dense materials, such as lead. Gamma rays are identical to x-rays but have a nuclear origin, rather than an atomic origin.

Gray (Gy) – The SI unit of absorbed dose. One gray is equal to an absorbed dose of 1 J kg^{-1} (100 rad).

Half-life – The time in which one half of the atoms of a particular radioactive substance disintegrate into another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical half-life.

Ion – An atom that has too many or too few electrons, causing it to be chemically active; an electron that is not associated (in orbit) with a nucleus.

Ionization – The process of adding one or more electrons to, or removing one or more electrons from, atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or nuclear radiations can cause ionization.

Ionizing Radiation – Any radiation capable of producing ions by displacing electrons from atoms or molecules. Some examples are alpha, beta, gamma and x-rays, and neutrons.

Isotope – One of two or more types of atoms with the same number of protons, but different numbers of neutrons in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the number denoting the approximate atomic weights. Isotopes of a given element are chemically identical, but differ slightly in mass and often have different physical or radioactive properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

Lens dose equivalent – The dose equivalent, upon external exposure of the lens of the eye, at a tissue depth of 0.3 centimeter (300 mg/cm^2).

Lethal dose – The dose of radiation expected to cause death in an exposed population. Lethal dose is often expressed as lethal dose X/Y (abbreviated LD X/Y), where X is the percentage of the population expected to die from the given dose after Y days. For example, lethal dose 50/60 means that 50% of the population is expected to die in 60 days. Typically, the LD 50/60 is generally accepted as 500 rad (5 Gy) received over a short period of time.

Low toxicity alpha emitter – Natural uranium, depleted uranium, natural thorium, uranium-235, uranium-238, thorium-232, thorium-228 or thorium-230 when contained in ores or physical or chemical concentrates or tailings; or alpha emitters with a half-life of less than ten (10) days.

Mixed waste – Radioactive waste that also meets the US EPA definition of being chemically hazardous.

Neutron – An uncharged particle with a mass comparable to (only slightly greater than) that of the proton, and found in the nucleus of every atom heavier than hydrogen.

Nuclide – A general term referring to any know isotope, either stable or unstable, of any chemical element. A radionuclide refers to an unstable, radioactive isotope. Approximately 2500 natural and artificial radionuclides (radioisotopes) have been identified.

Occupational radiation exposure – The radiation exposure or dose to an individual in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive materials. Occupational dose does not include dose received from: background radiation, as a patient from medical practices; from voluntary participation in medical research programs; or as a member of the general public.

Parent – A radionuclide that upon radioactive decay or disintegration yields a different nuclide (the daughter).

Personnel monitoring – The continuous measurement of an individual's exposure to external radiation by means of suitable devices, such as film badges, TLD or OSL badges, pocket dosimeters, or electronic dosimeters, worn on the individual's person.

Quality factor – A numerical factor assigned to describe the average effectiveness of a particular kind (and sometimes energy) of radiation in producing biological effects in the human. The factor used to derive equivalent dose from absorbed does.

QUALITY FACTORS AND ABSORBED DOSE EQUIVALENCIES

Types of Radiation	Quality Factor (Q)	Absorbed Dose Equal to a Unit Dose Equivalent[a]
X-, gamma, or beta radiation	1	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown energy	20	0.05
Neutrons of unknown energy	10	0.1

High-energy protons	10	0.1

[a]Absorbed dose in rad equal to one rem or the absorbed dose in gray equal to one sievert. If it is more convenient to measure the neutron fluence rate than to determine the neutron dose equivalent rate in rems per hour or sieverts per hour, one rem (0.01 Sv) of neutron radiation of unknown energies may, for purposes of the rules in 15A NCAC 11, be assumed to result from a total fluence of 25 million neutrons per square centimeter incident upon the body. If sufficient information exists to estimate the approximate energy distribution of the neutrons, the licensee or registrant may use the fluence rate per unit dose equivalent or the appropriate Q value from the following table to convert a measured tissue dose in rads to dose equivalent in rem.

MEAN QUALITY FACTORS, Q, AND FLUENCE PER UNIT DOSE EQUIVALENT FOR MONOENERGETIC NEUTRONS

Neutron Energy (MeV)	Quality Factor[a] (Q)	Fluence per Unit Dose Equivalent[b] (neutrons cm-2 rem-1)
2.5×10^{-8} (thermal)	2	980×10^{6}
1×10^{-7}	2	980×10^{6}
1×10^{-6}	2	810×10^{6}
1×10^{-5}	2	810×10^{6}
1×10^{-4}	2	840×10^{6}
1×10^{-3}	2	980×10^{6}
1×10^{-2}	2.5	1010×10^{6}
1×10^{-1}	7.5	170×10^{6}
5×10^{-1}	11	39×10^{6}
1	11	27×10^{6}
2.5	9	29×10^{6}
5	8	23×10^{6}
7	7	24×10^{6}
10	6.5	24×10^{6}
14	7.5	17×10^{6}
20	8	16×10^{6}
40	7	14×10^{6}
60	5.5	16×10^{6}
1×10^{2}	4	20×10^{6}
2×10^{2}	3.5	19×10^{6}
3×10^{2}	3.5	16×10^{6}
4×10^{2}	3.5	14×10^{6}

[a]Value of quality factor (Q) at the point where the dose equivalent is maximum in a 30-cm diameter cylinder tissue-equivalent phantom.
[b]Monoenergetic neutrons incident normally on a 30-cm diameter cylinder tissue-equivalent phantom.

Rad – The special unit of absorbed dose. One rad is equal to an absorbed dose of 0.01 J kg^{-1} (0.01 gray).

Radiation (ionizing radiation) – Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this manual, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light.

Radioactivity – The process of undergoing spontaneous transformation of the nucleus, generally with the emission of alpha or beta particles, often accompanied by gamma rays. The term is also used to designate radioactive materials.

Radioactive Material – Radioactive material is any material that contains radioactive atoms.

Radioactive Contamination – Deposition of radioactive material in any place where it may harm persons or equipment.

Radiation sickness (syndrome) – The complex of symptoms characterizing the disease known as radiation injury, resulting from excessive exposure of ionizing radiation (greater than 200 rads or 2 gray) of the whole body or a large area. The earliest of these symptoms are nausea, fatigue, vomiting, and diarrhea, which may be followed by loss of hair (epilation), hemorrhage, inflammation of the mouth and throat, and general loss of energy. In severe cases, where the radiation exposure has been approximately 1,000 rad (10 gray) or more, death may occur within two to four weeks. Those who survive six weeks after a single large dose of radiation may generally be expected to recover.

Rem – The special unit of any of the quantities expresses as dose equivalent. The dose equivalent in rem in equal to the absorbed dose in rad multiplied by the quality factor (1 rem = 0.01 sievert).

Roentgen (r) – A unit of exposure to ionizing radiation. It is that amount of gamma or x-rays required to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions. Named after Wilhelm Roentgen, German scientist who discovered x-rays in 1895.

Shallow-dose equivalent (H_S) – With respect to external exposure of the skin or an extremity, means the dose equivalent at a tissue depth of 0.007 centimeter (seven (7) mg/cm^2) averaged over an area of one (1) square centimeter.

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

State – The Commonwealth of Kentucky.

Total effective dose equivalent (TEDE) - The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Waste, radioactive – Solid, liquid, and gaseous materials from nuclear operations which are radioactive or become radioactive and for which there is no further use. Wastes are generally classified as high-level (having radioactivity concentrations of hundreds of thousands of curies per gallon or cubic foot), low-level (in the range of 1 microcurie per gallon or cubic foot), or intermediate level (between these extremes) (see 10 CFR Parts 60 and 61).

Whole body – For purposes of external exposure, whole body means the head, trunk (including male gonads), arms above the elbow, or legs above the knee.

Wipe test – A method of determining the removable contamination on a surface. The suspected area is wiped with a filter paper, cotton swab, or similar and the radioactivity on the wipe media is measured.

X rays – Penetrating electromagnetic radiation having a wavelength that is much shorter than that of visible light. Rays produced by excitation of the electron field around certain nuclei are called characteristic x-rays. Electromagnetic rays that are produced as the result of deceleration of charged particles as they pass near the nucleus are called continuous x-rays (or Bremsstrahlung). X-rays are identical to gamma rays, but originate outside the nucleus.

References

902 KAR 100:010. Definitions for 902 KAR Chapter 100.

Bernard Shleien, Lester A. Slaback, Jr., and Brian Kent Birky, eds. Handbook of Health Physics and Radiological Health. 3rd ed. Lippincott Williams & Wilkins, 1998.

Section 3. Administrative Organization

3.1 Scope

These guidelines apply to all departments, laboratories, and persons at WKU that receive, possess, use, transport or dispose of radioactive material and/or equipment.

3.2 Radiation Safety Committee (RSC)

Hereafter known as the RSC, receives its internal authority from the President of WKU. The RSC bylaws are located in Appendix A.

3.2.1 Responsibilities

a. To establish and continually review the radiation protection program at WKU so as to maintain human radiation exposures and radioactive effluent at levels which are As Low As Reasonable Achievable (ALARA) and always below the maximum levels as set forth by Kentucky (KY) and Federal Agencies.
b. To ensure WKU's compliance with radiation protection regulations promulgated by KY and Federal Agencies and with terms dictated by WKU's Radioactive Material License.
c. To annually review the training of WKU personnel in the proper use of radioisotopes and guidelines in activities related to radioisotopes.
d. To annually review the entire radiation protection program in accordance with documentation of discussion maintained in the minutes.

3.2.2 Authority

To meet these responsibilities, the RSC has been given the following authority:

a. To grant, deny, or suspend authorization to use radioactive material and/or equipment that emits ionizing radiation, by WKU personnel, while on WKU property. Such action by the RSC follows a review of information relative to the authorization in question.
b. To apply restrictions on the amount of occupational radiation exposure that any individual WKU personnel may receive during his/her associate with WKU upon the recommendation of the Radiation Safety Officer.
c. To establish and follow specific administrative guidelines for approval of the uses of radioactive material or equipment containing radioactive material.

3.3 Radiation Safety Officer

Hereafter known as RSO, is appointed by the President of WKU. Management shall provide sufficient time for the RSO to perform his/her duties and responsibilities.

3.3.1 Responsibilities

a. To ensure that radioactive material possessed or used by the applicant is limited to those materials specified in the license.
b. To ensure that the radioactive materials/devices are used only by those individuals, or under the supervision of individuals, authorized by the license.
c. To ensure that all users wear personal monitoring equipment (if required) such as film badges, optically stimulated luminescence (OSL) dosimeters, thermoluminescent dosimeters (TLD's), and/or pocket dosimeters.

d. To ensure that all reports of personnel exposure are reviewed in a timely manner.
e. To ensure that licensed material/gauges are properly secured against unauthorized removal at all times, when not in use.
f. To develop operating and emergency guidelines and to assist in personnel training and orientation in these guidelines.
g. To serve as a point of contact and give assistance in case of emergency and to ensure that proper authorities are notified promptly in case of an accident involving radioactive material/devices or other incidents that may involve the release of radioactive material (e.g. structural damage, fire, or theft).
h. To ensure that the terms and conditions of the license such as periodic leak tests are met and that the required records such a personnel exposure, leak tests, receipt, transfer, disposal, etc., are periodically reviewed for compliance with Cabinet regulations and the license conditions.
i. To provide oversight of radiation safety at all WKU use/storage locations.
j. To ensure that radioactive material is transported in accordance with all applicable DOT requirements.
k. To ensure that radioactive material is disposed of properly.
l. To report to the RSC any violations of established radiation safety guidelines, violations against the license, or violations against 902 KAR 100.
m. To maintain records and submit reports as required by KY and Federal Agencies.
n. To conduct internal audits at least annually to include radioisotope laboratory inspections, radiation surveys, and area monitoring. These audits shall (1) determine compliance with Cabinet and DOT regulations and the terms and conditions of the license, (2) evaluate the effectiveness of the radiation protection program content and implementation, and (3) ensure that required records are properly maintained.
o. To document (and maintain) audit results, identification of deficiencies, and recommendations for change, and to provide this information to the RSC.
p. To ensure that audit results and corrective actions are communicated to all personnel who use radioactive material/devices (regardless of their location or the license under which they normally work).
q. To have up-to-date copies of regulations 902 KAR 100, review new or amended regulations, and review license guidelines, as needed to comply with Cabinet regulations.
r. To ensure that all incidents, accidents, and personnel exposure to radiation in excess of ALARA or 902 KAR 100:019 limits are investigated and reported to the Cabinet and other authorities, as appropriate, within required time limits.
s. To ensure the license is amended whenever there are changes in: licensed activities or information or commitments provided to the Cabinet in the licensing process.

3.3.2 Authority

a. To terminate any activity employing radiation that is a threat to health or property after notification of the person in charge. (The RSC has final disposition of any disputes.)
b. To make recommendations to the RSC on granting, denying, or suspending the authorization to use radioactive materials and/or equipment that emits ionizing radiation, by WKU personnel, while on WKU property.
c. To recommend or order remedial action to correct safety deficiencies.
d. To approve/deny procuring, receiving and shipping all WKU radioactive material. This decision shall be made, in writing, prior to any transactions occurring.
e. To give provisional or emergency approval for the transfer or use of radioactive materials.
f. To designate a member of the RSC to act when the RSO is absent from WKU.

3.4 Department

3.4.1 Responsibilities

Each department in which radioactive material or equipment containing radioactive material is used is responsible for providing and maintaining:

a. limited access to areas where the material or equipment is used or stored.
b. equipment necessary to minimize exposure and possibility of contamination from radioactive materials, and to ensure compliance with the License and 902 KAR 100.
c. instruments necessary to monitor the types of radiation to which personnel may be exposed.
d. a clearly defined supervisor for each area using/storing the material or equipment.

3.5 Authorized User (AU)

Receives authority from the RSC to possess or use radioactive material, sources, or equipment as defined by the Radioactive Materials License. Only WKU Faculty/Staff may qualify as an AU.

3.5.1 Responsibilities

a. To submit a proposal (i.e. Radiation Work Permit) to the RSC, through the RSO, specifying the radioactive source or material including the individual possession limit, its intended use and disposition, and other information the RSO may deem necessary.
b. To inform the RSO of any proposed changes in materials, guidelines, or activities different from the approved ones.
c. To keep adequate up-to-date records of dispensing and disposal of radioactive material according to guidelines in this manual on forms that are either supplied by or approved by the RSO.
d. To maintain an up-to-date listing with the RSO of all Supervised Users.
e. To provide supervision for all Supervised Users under their authority.
f. To ensure that laboratory personnel wear the assigned monitoring devices (film badge, OSL, TLD, pocket dosimeter) or provide other prescribed monitoring samples (urinalysis), if required.
g. To ensure that laboratory personnel are properly instructed in the guidelines involving radiation sources.
h. To notify the RSO immediately of the theft or unaccountability of any radioactive material (including waste).
i. To notify the RSO immediately of overexposure or suspected overexposure, accidental skin contamination, inhalation, ingestion, or any other emergency involving radioactive material.
j. To establish appropriate guidelines to ensure compliance with the posting and labeling requirements of 902 KAR 100.
k. To ensure the necessary personal protective equipment is provided and maintained for his/her laboratory assistants (e.g. lab coats, gloves, tongs, bench pads, radiation shields, etc).
l. To establish a radioisotope-laboratory "close-down" procedure adequate to ensure that at the end of the work-day (which shall only apply to areas where “open-source” radioactive materials are used):
    1. Survey measurements and/or wipe tests are conducted to establish that external radiation and contamination levels are within permissible limits.
    2. Radiation sources are properly labeled and stored.
    3. Experiments that will be in progress after normal work hours will be properly attended.
    4. Each area using or storing radioisotopes is secured against unauthorized access.
m. Ensure that any of their Supervised Users that wish to declare pregnancy do so in writing to the RSO (i.e. as defined by 10 CFR 20.1003, so KY in U.S. NRC Regulatory Guide 8.13 attached as

Appendix K).

n. Additional requirements for radioactive gauge users are found in Appendix B.

3.5.2 Authority

a. To restrict laboratory activities involving radiation to those defined in the approved Radiation Work Permit (RWP).
b. To allow only Authorized or Supervised Users to handle or use radioactive materials, and/or ionizing radiation sources and allowing only authorized persons to enter rooms that are specified as restricted areas.

3.6 Supervised User – WKU Personnel (SU)

A Supervised User is appointed by the Authorized User who accepts supervisory responsibility for the Supervised User.

3.6.1 Responsibilities

a. To use radioactive material or equipment that emits ionizing radiation in a manner which complies with the guidelines and precautions contained in this document and with those established in the proposal (RWP) of the Authorized User under whom he/she works.
b. To control the radiation exposure to the lowest practical level and always below the levels in KAR 100:019.
c. To maintain laboratory records of the use and disposal of radioisotopes.
d. To be knowledgeable of emergency guidelines.
e. To notify the Authorized User immediately of any accident or spill involving radiation.
f. To practice laboratory techniques to control contamination of laboratory equipment and facilities.
g. To notify your Authorized User if you (female users) wish to declare pregnancy.

3.7 Supervised Users – Non-WKU Personnel (SU)

Are appointed by the Responsible Investigator who accepts supervisory responsibility for the Authorized User.

3.7.1 Responsibilities

See 3.6.1

3.7.2 Additional Requirements

a. Prior dose history must be submitted to the RSO.
b. May use dosimetry provided by non-WKU employer provided dosimetry is appropriate for the type of radiation expected and employer copies dosimetry results to WKU RSO at the end of each monitoring period (i.e., monthly, quarterly)
c. Dosimetry will be issued by WKU RSO if no dosimetry currently possessed by individual
d. Must complete WKU Radiation Safety Training as provided by the RSO

3.8 Visitors

Visitors may need to be in areas containing radioactive materials. In such cases, the visitor must have proper dosimetry (if needed), and be under direct physical supervision of the AU

Section 4. Regulatory and WKU Requirements

4.1 Agreement State Status

Section 274 of the Atomic Energy Act of 1954, as amended, provides a statutory basis under which NRC relinquishes to the States portions of its regulatory authority to license and regulate byproduct materials (radioisotopes); source materials (uranium and thorium); and certain quantities of special nuclear materials. The mechanism for the transfer of NRC's authority to a State is an agreement signed by the Governor of the State and the Chairman of the Commission, in accordance with section 274b of the Atomic Energy Act.

On March 26, 1962, the Commonwealth of Kentucky became the first Agreement State.
Source: http://www.nrc.gov/about-nrc/state-tribal/agreement-states.html

4.2 Commonwealth of Kentucky, Department for Public Health, Cabinet for Health and Family Services, Radiation Health Branch

The mission of the Radiation Health Branch is to:

1. Ensure the beneficial use of radiation; and
2. Protect the public from unnecessary exposure to the harmful effects of radiation.

The Commonwealth of Kentucky is a Nuclear Regulatory Commission (NRC) Agreement State. This means the NRC has relinquished regulatory control for oversight of all Atomic Energy Act (AEA) activities in Kentucky except for federal facilities and certain quantities of special nuclear material.

Kentucky also utilizes the Conference of Radiation Control Program Directors' suggested state regulations. These regulations provide uniformity on a national level.

The Radiation Health Program is responsible for licensure, registration, and certification of all uses of radiation. The program conducts inspections, reviews and validates environmental surveillance data, and manages compliance activities. The Program is responsible for statewide emergency response to radiological incidents and emergencies and is equipped to respond to radiological emergencies 24 hours a day (Kentucky Emergency Management Duty Office (502) 607-1637.

Source: http://chfs.ky.gov/dph/radiation.htm

4.3 Radioactive Material License

The use of radioactive materials at WKU is conducted under the authority of its specific license issued by the Kentucky Cabinet for Health & Family Services.

The license covers all licensed radioactive materials use for the entire university. Any individual or action that jeopardizes the license endangers the permission of all authorized individuals who use radioactive materials at WKU. Therefore, this license places significant responsibility on individuals who use radioactive materials to conform to safe work practices, and to conduct and complete all required license activities in the course of their use of radioactive materials.

4.4 Regulations

The use, storage, transportation, and disposal of radioactive material must conform with the applicable regulations of the Cabinet for Health and Family Services of the Commonwealth of Kentucky, as well as all other pertinent federal and state regulations, the conditions of WKU's license, and the conditions set forth in the Authorized User's Radiation Work Permit (RWP).

Regulations pertaining to the use of radioactive materials are found in the Kentucky Administrative Regulations (KAR) Title 902 Chapter 100. Copies of the most current regulations can be viewed at http://www.lrc.state.ky.us/kar/TITLE902.HTM.

4.5 Notice to Employees

KY regulations require that the "Notice to Employees" posting is available to radiation workers. This posting is displayed in all radioactive materials areas throughout the university. This notice provides information regarding the responsibilities of both the radiation worker and the employer.

4.6 Reporting Concerns and Suspected Violations

If you believe that a violation of KY's regulations or the WKU's license has occurred, report the violation to the Authorized User supervising the work or area involved. If you believe that adequate corrective action has not been taken, notify the RSO at 745-6200. You also have the right to contact the KY Radiation Health Branch at (502) 564-3700.

4.7 Access to Information

State regulations require WKU to provide workers access to certain notices, instructions, and reports, and the options available to individuals regarding safety concerns and suspected violations.

Faculty, staff, and students at WKU may examine copies of the following documents at the Department of Environmental Health & Safety office located at 1716 Park Street, or by contacting the RSO at 745-6200.

- CHFS regulations and inspection reports for radioactive materials
- The WKU Radioactive Material License
- Individual dosimetry reports (dosimetry reports will only be shown to the individual for whom the report belongs unless written authorization is provided by that individual.

4.8 Internal Audits

4.8.1 Annual Audits

Annual audits shall be conducted for each radioactive materials use area by the RSO or a suitable individual designated by the RSO. The audit format will generally be that format specified in KY Radiation Health Branch licensing guides. However, the audit formats may be modified as necessary to address unique aspects of a given use area.

4.8.2 Notices of Violation

In addition to the annual audits, Radiation Safety Violation Reports will be issued by the RSO if deficiencies are noted at times between the formal annual audits. These reports will be issued for deficiencies as simple as outdated license postings or improper survey documentation up through violations that pose a threat to health and safety. Identified violations will be reported to the KY Radiation Health Branch when the violation is required by 902 KAR 100 to be reported.

Section 5. Radiation Safety Training Requirements

5.1 Initial Radiation Safety Training

5.1.1 Radioactive Material Users

Initial radiation safety training is required for all radiation workers prior to the use of any licensable quantities of radioactive material. This training is also a prerequisite to obtaining a personal dosimeter. The initial radiation training may be provided as a combination of both online and classroom training. To request radiation safety training, please submit the online training request form located at

http://www.wku.edu/ehs/radiation/.

If you have any questions, contact the RSO at 745-6200.

Training topics shall include, as applicable:

- General radioactive materials safety
- Personnel dose monitoring program
- Radiation and contamination survey program
- Accident, incident, and emergency guidelines
- Radioactive material ordering, receipt, and package opening guidelines
- Storage and security
- Use of radioactive materials
- Radioactive waste storage, disposal, packaging, etc.
- Transportation
- Applicable state and federal rules and regulations and radioactive material license conditions

Note: In addition to the initial radiation safety training provided by the RSO, Authorized Users shall train all users under their supervision on specific guidelines relating to use of the radioactive material/equipment that they are licensed to use.

5.1.2 Ancillary Personnel

Ancillary personnel are those individuals at WKU that do not use radioactive material, but whose job duties may require them to work in the vicinity of radioactive materials. Ancillary personnel may include faculty, office staff, building services attendants (BSA), maintenance staff, etc. These individuals are required to receive an initial radiation safety awareness training provided by the RSO before assuming duties in the vicinity of radioactive materials.

Training topics shall include:

- Applicable portions of the radioactive material license pertinent to radiation safety
- Identification of areas where radioactive material is used or stored
- Potential hazards associated with radioactive material
- Radiological safety guidelines appropriate to their respective duties
- Pertinent state and federal regulations
- Rules and guidelines of the license
- Obligation to report unsafe conditions to the RSO
- Appropriate response to emergencies or unsafe conditions
- Right to be informed of their radiation exposure and bioassay results, as applicable

- Locations where the licensee has posted or made available notices, copies of pertinent regulations, and copies of pertinent licenses and license conditions (including applications and applicable correspondence), as required by 902 KAR 100:165.

5.2 Radiation Safety Refresher Training

5.2.1 Radioactive Material Users

Individuals using licensed quantities of radioactive material are required to attend an annual radiation safety refresher training. If a licensed user has not used or will not be using radioactive material for longer than one year, annual refresher training is not required. However, this user is required to attend a refresher training prior to resuming use. Contact the RSO at 745-6200 for more information regarding the training needs for your particular department or job function.

5.2.2 Ancillary Personnel

Periodic refresher training will be provided ancillary personnel as deemed necessary by the RSO.

5.3 Individuals Who Operate Gauges

5.3.1 Niton Portable XRF Gauge Users

Users of the Niton portable XRF shall, at a minimum, read and be familiar with the manufacturer's radiation safety and operating procedures as presented in the user's manual. Hands on training in the safe use of the XRF shall be provided by the RSO. Where feasible, it is recommended that the user attend training provided by Thermo Niton, which addresses radiation safety and operating procedures. If the manufacturer training is attended, the user shall still meet with the RSO to discuss WKU-specific requirements for use of the XRF.

5.3.2 Fixed Gauge Users

Users involved in the routine operation (this does not include maintenance, repair, installation, etc.) of a fixed gauge shall receive training from the gauge manufacturer prior to operation. This can be received at the time of gauge installation. Subsequent training for new users shall be arranged through the manufacturer unless alternate training is approved by the KY Radiation Health Branch. Training provided by the WKU RSO regarding WKU-specific requirements must also be completed prior to operation.

Section 6. Universal Safety Guidelines and Requirements

6.1 ALARA

An essential (and required) component of the radiation safety program is the use of ALARA to keep radiation doses to employees and members of the public as low as possible. The three primary ways to achieve ALARA are time, distance and shielding. Each of these is described in more detail below. More detail on ALARA action levels is located in Section 7 if this manual

6.1.1 Time

Radiation dose is directly proportional to the length of time an individual is exposed to a source of ionizing radiation. Therefore, the less time spent near a radiation source, the smaller the total dose received.

6.1.2 Distance

Distance is one of the simplest and most effective means of reducing radiation exposure. The relationship between distance and dose rate from a radiation point source follows the inverse square law. This means, that as a rough approximation, doubling the distance from a point radiation source can reduce the exposure rate by up to a factor of 4. Therefore, increasing the distance from the radiation source can significantly reduce radiation exposure. The use of tongs or other handling devices that increase distance from radioactive material during manipulation can significantly reduce extremity and body exposures.

6.1.3 Shielding

Properly shielding sources of radiation and/or personnel working near a source of radiation can dramatically reduce radiation exposure. It is important to choose shielding appropriate for the type of radiation and use involved. Shielding is available in a variety of forms for various applications. Contact the RSO for guidance regarding shielding types, application, and suppliers.

6.2 Radiation Signs and Labels

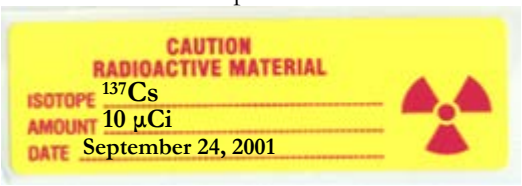
There are various radiation signs and labels that are required to be used according to 902 KAR 100:019. These include radioactive material labels, radiation area signs, etc.

6.2.1 Radioactive Material Use or Storage Areas

Each area storing or using radioactive material shall be posted by the RSO or under the direction of the RSO. These signs shall be removed only by, or with the approval of, the RSO. The RSO shall also be notified when posting/labeling signs need to be replaced. A conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" must be posted in an area or room in which there is used or stored an amount of licensed material exceeding ten (10) times the quantity of the material specified in 902 KAR 100:030. For example, 902 KAR 100:030 specifies 10 μCi for ^{137}Cs. So a location using or storing more than 100 μCi of ^{137}Cs would require a posting like that pictured below.

6.2.2 Labeling of Sources or Containers of Radioactive Materials

A radioactive source or a container holding a radioactive source must be labeled "Caution, Radioactive Material" if the activity in the source or container equals or exceeds the values stated in 902 KAR 100:030. For example, 902 KAR 100:030 specifies 10 µCi for ^{137}Cs. So a 10 µCi source of ^{137}Cs or a container with a total of 10 µCi or more within would require a label indicating "Caution, Radioactive Material." In addition to this wording, the radionuclide name, activity, and date of the activity are required. So, the label for the example ^{137}Cs source would look something like this:



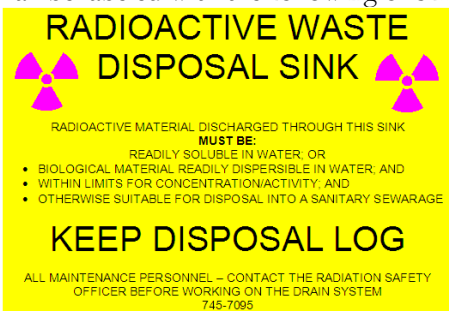
6.2.3 Labeling of Equipment Containing Neutron Generators

Equipment containing neutron generators must have the following label placed on its exterior as near as possible to the neutron production location.

6.2.4 Hot Sink Labeling

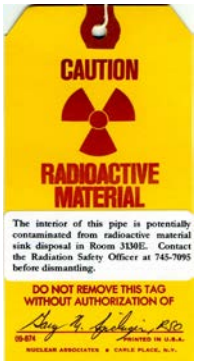
6.2.4.1 Hot Sinks

Designated hot sinks shall be labeled with the following or similar label.



6.2.4.2 Drains from Hot Sinks

The drain pipe leading from the hot sink should be labeled at its accessible points throughout the building with a label similar to that pictured below.



6.2.5 Radiation Areas

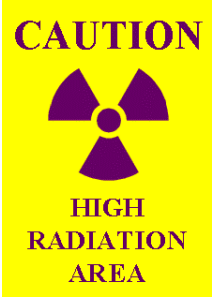
The following signs must be used to post Radiation Areas, High Radiation Areas and Very High Radiation Areas. The definition of each type of area and an appropriate example of a sign for that type of area appear below.

6.2.5.1 Radiation Area

An area, accessible to individuals, in which there exists radiation at levels that an individual may receive in excess of five (5) mrem in one (1) hour at thirty (30) centimeters from the radiation source or from a surface that the radiation penetrates.

6.2.5.2 High Radiation Area

An area, accessible to individuals, in which radiation levels may result in an individual receiving a dose equivalent in excess of 100 mrem in one (1) hour at thirty (30) centimeters from the radiation source or from a surface that the radiation penetrates.



6.2.5.3 Very High Radiation Area

An area, accessible to individuals, in which radiation levels may result in an individual receiving an absorbed dose in excess of 500 rads in one (1) hour at one (1) meter from a radiation source or from a surface that the radiation penetrates. At very high doses received units of absorbed dose (such as rads) are appropriate, rather than units of dose equivalent (such as rems).

6.2.5.4 Airborne Radioactivity Area

A room, enclosure, or area in which airborne radioactive material, composed wholly or partly of radioactive material, exists in concentrations:

- In excess of the derived air concentrations specified in 902 KAR 100:019, Section 44; or
- That an individual present in the area without respiratory protective equipment may exceed an intake of six-tenths (0.6) percent of the annual limit on intake or twelve (12) DAC hours

6.3 Leak Testing

Leak testing is to be conducted every 3 months for sealed or foil alpha-emitting radioactive sources. Beta and/or gamma-emitting sealed or foil sources must be leak tested every 6 months. In both cases the leak test analysis must be capable of detecting the presence of 0.005 µCi of radioactivity on the leak test media.

If the leak test reveals the presence of 0.005 µCi or more of removable contamination, the source must be immediately withdrawn from use. The source must then be decontaminated, repaired, or properly disposed as radioactive waste. All equipment which has been in contact with the leaking source shall be checked for contamination and decontaminated. A report within five (5) days of the test describing the equipment involved, the test results and the corrective actions taken shall be filed with the KY Radiation Health Branch, as indicated by 902 KAR 100.

Leak testing shall be done by the RSO or an approved vendor.

6.4 Quarterly Sealed Source Inventory

A quarterly physical inventory is required to account for all licensed sealed sources. The inventory must include the radionuclides, activities, manufacturer's name and model numbers, the location of the sealed sources, the date(s) of the inventory, and the name of the individual conducting the inventory. Though not required by license, the WKU quarterly physical inventory also accounts for all license-exempt sealed sources.

6.5 Unsealed Source Inventory

Please refer to **Section 17. Radioactive Waste** for a description of the use and disposal records that must be maintained for unsealed source use. The forms described will provide the mechanism for reporting unsealed source inventories on a monthly basis during active use periods.

6.6 General Rules for Safe Use of Radioactive Material

- Wear a laboratory coat or other protective clothing at all times in areas where unsealed radioisotopes are used.
- Wear disposable gloves at all times when handling unsealed radioisotopes.
- After each procedure using unsealed radioisotopes or before leaving the area, monitor hands, shoes, and clothing for contamination.
- Do not eat, drink, smoke or apply cosmetics in any area where radioactive material is stored or used.
- Do not store food, drink or personal effects in areas where radioactive material or used.
- Wear personal dosimetry, if required, at all times while in areas where licensed radioactive materials are used or stored.
- Dispose of radioactive waste only in designated, labeled and properly shielded receptacles or in designated hot sinks.
- Never pipette radioactive solutions by mouth.
- Store radioactive materials/solutions in container clearly labeled with the name of the compound, radionuclide, activity and date of the activity.
- Secure all radioactive material when it is not under the constant surveillance and immediate control of the user(s).
- Whenever practical, the user(s) should perform a trial experimental run using stable (or low activity) material to establish the adequacy of guidelines and equipment.
- When performing operations that might produce airborne contamination (i.e., transfers of unsealed powdered or volatile radioactive material), approved exhaust ventilation shall be used. When recommended by the RSO, filtration for effluent air or the containment of activity by glove bags or glove boxes shall be provided.
- Use plastic-backed absorbent pads on work benches when practical.

6.7 Fume Hoods

Radioactive material operations producing aerosols volatile compounds, or fine dusts should be performed in a fume hood that has a currently dated flow check sticker. Contact the RSO at 745-6200 for additional information on specific use requirements, or to schedule an airflow performance check.

6.8 Facility Maintenance and Renovation

All facilities in which radioactive materials have been used or stored need to be surveyed by the RSO prior to maintenance or renovation activities. This survey is not required in areas that have already undergone a documented and approved decommissioning.

6.9 Equipment Service and Surplus

Any equipment or items used to manipulate or store radioactive material must be free of radioactive contamination prior to disposal or being serviced. Contact the RSO for guidance on release surveys.

6.10 Calibration Requirements for Radiation Monitoring Instruments

Radiation monitoring instruments used for quantitative radiation measurements are required, by regulation, to be calibrated annually. Survey instruments that have never been calibrated or are out-of-calibration cannot be used for quantitative radiation survey measurements. Instruments found out-of-calibration by the RSO will be tagged as "out-of-service." Instrument calibrations must be performed by an appropriately licensed vendor.

6.11 Written Operating Procedures and/or User's Manuals

Written operating/use procedures and applicable user's manuals must be located such that any user can refer to these documents quickly when needed.

6.12 Other Required Postings

The following additional items are required to be posted conspicuously in each radioactive materials use area. If it is not practical to post these items, a notice must be posted that indicates where the documents can be viewed or obtained. If you need assistance obtaining these postings, please contact the RSO.

6.12.1 KY Administrative Regulations

- 902 KAR 100:019 – Standards for Protection Against Radiation
- 902 KAR 100:165 – Notices, Reports, and Instructions to Employees

6.12.2 Radioactive Material License

Section 7. Dose Limits and Assessment

7.1 Maximum Permissible Dose Limits

Exposure to ionizing radiation, both internal and external, shall be maintained As Low As is Reasonably Achievable (ALARA). All radiation users shall make every reasonable effort to maintain radiation exposures and releases of radioactive materials in effluents to unrestricted areas as low as is reasonably achievable. The term "as low as reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, the economics of improvements in relation to benefits to the public health and safety, other societal and socioeconomic considerations, and in relation to the utilization of sources of radiation in the public interest. The external and internal exposure from sources of radiation shall be controlled in such a way as to provide reasonable assurance that no individual shall receive radiation dose in excess of the values stated in 902 KAR 100:019.

7.1.1 Radiation Workers

Maximum permissible dose limits for adult radiation workers (listed below) apply to any combination of dose received from external or internal exposure. These limits do not apply to doses received from background radiation or from medical procedures or exams. An adult radiation worker is defined as an individual 18 years of age or older that works with or around sources of radiation.

Annual Occupational Dose Limits for Adults		
5,000 mrem (5 rem)	50 mSv (0.05 Sv)	Total Effective Dose Equivalent (TEDE)
50,000 mrem (50 rem)	500 mSv (0.5 Sv)	DDE + CEDE to any individual organ or tissue other than the eye
50,000 mrem (50 rem)	500 mSv (0.5 Sv)	Shallow Dose Equivalent (SDE)
15,000 mrem (15 rem)	150 mSv (0.15 Sv)	Lens of Eye Dose Equivalent (LDE)

7.1.2 Declared Pregnant Radiation Worker

Under state and federal law, the TEDE of a pregnant radiation worker remains at 5,000 mrem (50 mSv) per year until she specifically declares her pregnancy in a written and signed statement directed to the RSO. The declaration is voluntary. Following the RSO's receipt of a signed pregnancy declaration, the dose limit to the worker's embryo/fetus is limited to 500 mrem (5 mSv) for the duration of her pregnancy. Upon the receipt of a signed pregnancy declaration, the RSO will provide additional dosimetry to monitor potential internal and/or external exposure to the embryo/fetus as appropriate. A copy of the pregnancy declaration form is available in Appendix N of this manual.

The RSO recommends that a pregnant radiation worker declare her pregnancy so that her occupational radiation exposure potential can be evaluated to ensure that the dose to the unborn child does not exceed 500 mrem (5 mSv) over the duration of the pregnancy.

7.1.3 Minor Radiation Worker

The maximum permissible dose limits for individuals under the age of 18 are 10% of the adult limits specified above.

7.1.4 General Public

The Total Effective Dose Equivalent (TEDE) to a member of the general public (including WKU employees not involved in working with sources of ionizing radiation) is 100 mrem (1 mSv) per year from licensed or registered activities at WKU. In addition, the dose to a member of the public from external radiation shall not exceed 2 mrem (0.02 mSv) in any one (1) hour.

7.2 ALARA Program

The maximum permissible occupational dose limits established by regulation are based on limiting individual radiation dose to what is considered to be an acceptable level of occupational risk. Although there is no documented evidence linking any health effect with exposures less than 10,000 mrem (100 mSv) delivered at a high dose rate, it is assumed that any radiation exposure may carry some risk. Therefore, regulation requires that WKU provide a program designed to reduce exposures As Low As Reasonably Achievable (ALARA) to the extent practical, utilizing procedural and engineering controls.

WKU's ALARA Program provides a process for the RSO and the RSC to review the radiation safety program annually, review all proposals (i.e. RWPs) for radioactive material usage, review all occupational radiation exposure reports, and investigate any occurrences where occupational exposures exceed established program action levels.

7.2.1 Action Levels

WKU has established investigational levels for occupational exposure to radiation.

7.2.1.1 Operational Action Level

The RSO contacts individuals and their supervisor/department head if their monthly/quarterly exposure exceeds any of the action levels listed in the following table.

7.2.1.2 Action Level I

In addition to "Operational Action Level" notifications, the RSO requires the completion of a questionnaire for "Action Level I" exposures.

7.2.1.3 Action Level II

In addition to operational and Level I actions the RSO requires a meeting with the staff member and supervisor regarding exposures in this category.

Action Levels (per calendar quarter)			
	Operational	Level I	Level II
TEDE	125 mrem (1.25 mSv)	*375 mrem* *(3.75 mSv)*	*625 mrem* *(6.25 mSv)*
SDE	*1,250 mrem* *(12.5 mSv)*	*3,750 mrem* *(37.5 mSv)*	*6,250 mrem* *(62.5 mSv)*
LDE	*375 mrem* *(3.75 mSv)*	*1,125 mrem* *(11.25 mSv)*	*1,875 mrem* *(18.75 mSv)*
DDE + CEDE *(Any organ or tissue other than the eye)*	*1,250 mrem* *(12.5 mSv)*	*3,750 mrem* *(37.5 mSv)*	*6,250 mrem* *(62.5 mSv)*

7.2.1.4 Action Levels for Minors

The action levels for a minor are 10% of the limits listed above.

7.2.1.5 Action Levels for Declared Pregnant Worker

The action levels for a declared pregnant worker are

- Operational - 5 mrem per month
- Level I - 15 mrem per month
- Level II - 25 mrem per month.

7.3 Determination of Exposure

7.3.1 Dosimeters

Personal dosimeters used to record occupational radiation exposures are supplied and processed through an NVLAP (National Voluntary Laboratory Accreditation Program)-approved commercial dosimeter service. The administration and management of the personnel monitoring program is provided by RSO. Personal dosimeters are assigned to individuals based upon regulatory requirements and their potential for occupational exposure to penetrating radiation. Dosimeters are also available upon request regardless of regulatory requirements. Dosimeters are normally exchanged on a monthly or quarterly basis. Annual summaries of dosimetry reports are provided to each dosimeter holder and are maintained on file by the RSO. Contact 745-6200 if you have questions concerning dosimeters or dosimeter reporting.

Documented completion of RSO-provided radiation safety training applicable to job function is required as a prerequisite to obtaining a personal dosimeter. Contact the RSO at 745-6200 for more information regarding applicable training for your job function.

7.3.1.1 Conditions Requiring External Dosimetry

Dosimetry is required for:

a. Adults likely to receive, in one (1) year from sources external to the body, a dose in excess of ten (10) percent of the limits specified in this section.
b. Declared pregnant women likely to receive, in one (1) year from sources external to the body, a dose in excess of ten (10) percent of the applicable limits specified in this section.
c. Individuals entering a high or very high radiation area.

7.3.1.2 Types of Dosimeters

Whole Body
Whole body dosimeters provide measurement of penetrating and non-penetrating radiation dose. Penetrating radiation is designated on reports as "DDE" for deep dose equivalent and includes exposure to the whole body (head, trunk, active blood-forming organs, and reproductive organs). Non-penetrating radiation is designated as "SDE" for shallow dose equivalent, and includes exposure to the skin and extremities. Lens of the eye dose equivalent is designated as "LDE." Whole body dosimeters are to be worn on the torso in the region likely to receive the highest radiation exposure.

Ring Dosimeters
Ring dosimeters provide measurement of radiation exposure to the extremities (hands and forearms). The ring dosimeter is to be worn under your disposable glove, if applicable, and on the hand most likely to receive the highest radiation dose.

Other Dosimeters
Dosimeters are also available for other extremities. Contact the RSO to discuss these other dosimeter types.

7.4 Determination of Internal Exposure

7.4.1 Bioassays

Thyroid and/or urine bioassays are performed for personnel for whom internal exposure to radioactive materials is considered most likely. Bioassays are normally performed for:
•Individuals using large quantities of open (unsealed) radioactive materials as determined by the RSO.
•Declared pregnant radiation workers working with unsealed radioactive material.
•Individuals with an accidental or suspected intake of radioactive material.

Monitoring of the occupational intake (internal exposure) is required for:

1. Adults likely to receive, in one (1) year, an intake in excess of ten (10) percent of the applicable ALIs in Section 44(9), Table I, Columns 1 and 2, of 902 KAR 100:019
2. Declared pregnant women likely to receive, in one (1) year, a committed effective dose equivalent in excess of 0.05 rem (five-tenths (0.5) mSv).

7.4.2 Accidental Internal Exposure Assessment

Anyone suspecting that they have had an intake of radioactive material through any pathway (e.g., ingestion, injection, inhalation, or skin absorption) should contact the RSO immediately at 745-6200 so that an evaluation can be performed.

Section 8. Obtaining Authorization

8.1 Use of Radioactive Materials

WKU faculty/staff requesting authorization to use licensed radioactive material for any reason shall obtain approval from the WKU Radiation Safety Committee (RSC) prior to assuming responsibility for the material. Permission to obtain and use license-exempt radioactive material shall be received from the WKU Radiation Safety Officer.

Prospective individuals appointed to serve as the WKU RSO must obtain approval from the CHFS prior to assuming any one of these responsibilities.

8.2 Authorized User Application

Faculty/staff requesting permission to possess licensed radioactive materials must submit evidence of qualifications of training and experience to the RSC for review and approval prior to assuming responsibility.

Requests for approval to be an Authorized User must be made in writing. The Authorized User application is found in Appendix C. The Authorized User application shall be submitted along with a Radiation Work Permit application (Appendix D). These written requests for authorization should be sent to the RSO.

Note: The Authorized User application and Radiation Work Permit are submitted concurrently only for an individual's initial request to become an Authorized User. An individual typically submits the AU application only once. An RWP, however, is submitted any time the conditions detailed below are met.

8.3 Radiation Work Permit Instructions

If an AU wishes to use a licensed radioactive material at WKU, then he/she must have an approved Radiation Work Permit (RWP).

The RWP and its supporting documents (in Appendix D) shall be completed by the primary Authorized User and submitted to the RSO for review. The RSO shall then review and send copies of the RWP to all members of the Radiation Safety Committee (RSC) for their review. If the RWP is approved by the RSO and the RSC, then the AU shall be allowed to utilize the radioactive material under the conditions of the RWP and the WKU Radioactive Material License. If the Radiation Work Permit is for a radioisotope that is not currently on the WKU Radioactive Material License or in a building that is not currently on the license, an amendment request to add that isotope and/or building to the license will be sent to the KY Radiation Health Branch after its approval by the RSC. Only after the Branch has issued an amendment approving the new isotope and/or building shall the individual be able to use that isotope.

If the AU needs to make a change to the RWP after it has been approved, then he/she must submit an amendment request (Appendix E) or an entirely new RWP (depending on the amount of change required). The amended RWP will undergo the full approval process as previously described.

Authorized Users will be required to submit a new Radiation Work Permit once every 5 years. In addition, the RSO and/or RSC reserve the right to request updated information, as they deem appropriate, from an AU regarding their work with radioactive material.

Section 9. Acquisition of Radioactive Materials

9.1 General Requirements

No radioactive material or equipment containing radioactive material may be received without the prior written approval of the RSO and RSC. This includes:

- Newly ordered material/equipment
- Material/equipment received from licensed transfer of material
- Material/equipment on loan
- Donated material/equipment

Radioactive materials are also required to be shipped to and received by the RSO.

9.2 Procurement

9.2.1 Licensable Radioactive Material

No licensable radioactive material shall be purchased using credit cards.

Prior to ordering licensed radioactive material, a Radioactive Material Acquisition Pre-Approval Form, located in Appendix F, must be completed by the AU and submitted to the RSO for approval. Once this has been approved, the RSO shall return the completed form to the AU and forward a copy to the WKU Department of Purchasing. The AU may then proceed with the submission of an online purchase requisition in Banner.

If recurring radioisotope acquisitions are anticipated for a given WKU fiscal year, then a standing purchase order should be requested through Banner. A standing purchase order would allow the AU to specify the anticipated total activity and cost of radioisotope to be acquired during the current fiscal year. If a standing order is set up, the AU must notify the RSO before each radioisotope order, but the purchase order will already be in place with the vendor. Upon notification of the RSO, the AU may place the radioisotope order by telephone or fax by referencing the existing standing purchase order number. This procedure allows for a more efficient and timely ordering and receipt of routine licensed radioisotope purchases.

The Department of Purchasing will not process a purchase requisition without the completed Radioactive Material Pre-Approval Form. The ordering Authorized User shall send the RSO a copy of the purchase order immediately following its receipt from Purchasing. No radioactive materials may be ordered prior to this transaction occurring, including purchases made with grant funds.

When a purchase requisition is entered in Banner, the "Ship To:" code must be changed to *146* (Environmental Health & Safety). The "Attention To" line should indicate *Radiation Safety Officer*. Specific commodity codes and account codes have been added to Banner for use in online purchase requisitions for radioactive materials, including repair/maintenance/calibration of currently owned material or equipment containing material. These commodity codes must be used as they add the RSO to the electronic approval queue for radiation-related online purchase requisitions.

Radioactive material ordered via purchase orders initiated by online purchase requisitions shall be shipped to:

Western Kentucky University
Central Receiving (146)
1906 College Heights Boulevard
Bowling Green, KY 42101

9.2.1.1 Banner Radiation Commodity Codes

The Banner radiation commodity codes and their intended uses are listed below:

545060 - Radioactive Supplies
Radioisotope purchases (sealed sources like Cs-137, Co-60, etc., unsealed sources like H-3, C-14, P-32, etc.)

545090 - Laboratory - Radiation Equipment <$500
Radiation-producing machines or equipment containing radioactive materials (e.g., x-ray tubes, neutron generators, gauges, survey instruments containing check sources)

545100 - Laboratory - Radiation Equipment >$500
Radiation-producing machines or equipment containing radioactive materials (e.g., x-ray tubes, neutron generators, gauges, survey instruments containing check sources)

545210 - Laboratory - Maintenance - Radiation Equipment
Any of the above-listed equipment needing to be shipped to a vendor for repair, calibration, or maintenance or for which a vendor will be paid to conduct these services on-site.

9.2.2 License-Exempt Radioactive Material

License-exempt radioactive materials may be purchased either by online requisition or by the use of a WKU-issued credit card. For license-exempt radioactive materials no Radioactive Material Acquisition Pre-Approval Form needs to be filled out, but RSO approval must still be obtained before the order is placed. This request for approval must be submitted to the RSO in writing (via e-mail is preferred) and the approval given in writing (also via e-mail). If you are unsure whether the quantity of radioactive material you would like to purchase is license-exempt, please contact the RSO. When a credit card is used as the order/payment method, the delivery address given the vendor must be:

Radiation Safety Officer
Western Kentucky University
Central Receiving V146
1906 College Heights Boulevard
Bowling Green, KY 42101

9.3 Additional Acquisition Notes

Written records for all ordering and receipt must be maintained.

During normal working hours, radioactive packages are delivered to Central Receiving at the Department of Shipping and Receiving. Shipping and Receiving notifies the RSO of the arrival of the package. At that point, the RSO will ensure the package is acceptable and that all pertinent records are retained, and shall then deliver the package to the appropriate AU. In certain instances, the RSO may help the AU to arrange delivery of the radioactive material directly to the applicable radiation lab.

During off-duty hours (before 8 a.m., after 4:30 p.m., or any time on weekends) no delivery of radioactive packages shall be accepted. If a delivery is needed during normally off-duty hours, provide the RSO at least two days advance notice.

Section 10. Package Receiving and Opening Requirements

10.1 Monitoring Requirements

Upon receipt of

a. a labeled package containing radioactive material in excess of Type A** quantity limits,
b. any package containing liquid radioactive material in excess of exempt quantities as specified in 902 KAR 100:080 and 085 and/or
c. any package (regardless of quantity limits) that arrives in a crushed, wet, or otherwise damaged condition,

the following must occur:

- Put on gloves to prevent hand contamination
- Visually inspect package for any sign of damage (e.g., wetness, crushed). If damage is noted, stop procedure and notify RSO.
- Measure the radiation level at 1 meter from the external surface of the package. If the measured radiation levels exceed the limits specified in Table 10-2, stop procedure and notify the RSO.
- Measure the radiation level at the surface of the package. If the measured radiation levels exceed the limits specified in Table 10-2, stop the procedure and notify the RSO.
- Wipe test the external surface of the package for removable radioactive contamination, unless the package contains only radioactive material in the form of a gas or in special form; if the measured removable contamination exceeds the limits specified in Table 10-1, stop the procedure and notify the RSO.
- Open the package with the following precautionary steps:
- Place a package containing a volatile compound in a fume hood before proceeding.
- Open the outer package according to the vendor's directions (if available) and remove the packing slip.
- Open the inner package and verify that the contents agree with those on the packing slip.
- Check the integrity of the final source container (i.e., inspect for breakage of seals, source capsules, vials, loss of liquid, discoloration of packing material, etc.)
- Verify that the source activity does not exceed the possession limits specified in your Radiation Work Permit.
- For unsealed sources only - Wipe test the external surface of the final source container to determine the amount of removable radioactivity (e.g., dpm/100 cm2, etc.). Take precautions against the spread of contamination as necessary.
- For sealed sources only - If the radioactive material is a licensed sealed source and a current leak test (within last 3 months for alpha emitters and within last 6 months for beta/gamma emitters) is not included in the shipment, then the source itself must be leak tested before use. The leak test shall show no removable contamination above 0.005 μCi.
- Monitor the packing material and packages for contamination before discarding.
- If contaminated, treat as radioactive waste.
- If not contaminated, obliterate radiation labels before discarding in regular trash.
- Record all of the monitoring results for the package using the "Radioactive Shipment Receipt Report" found in Appendix G.
- The monitoring must take place as soon as practical but no later than 3 hours after package receipt if it is received during normal working hours. If the package is received after normal working hours the monitoring must take place no later than 3 hours from the beginning of the next working day.

10.2 Exceptions to the Monitoring Requirements

No specific surveys or wipe tests are required:

- For packages containing non-liquid radioactive material in quantities less than the Type A limits
- Non-liquid tritium sources (including D-T neutron generator accelerator heads)

10.3 Emergency Notifications

The final delivery carrier and the KY Radiation Health Branch will be notified if:

- Removable surface contamination exceeds the limits specified in Table 10-1
- External radiation levels exceed the limits specified in Table 10-2
- Leak test results for a sealed source are in excess of 0.005 μCi

Table 10-1

Contaminant	Maximum permissible limits	
	μCi/cm²	dpm/cm²
Beta and gamma emitters and low toxicity alpha emitters	10^{-4}	220
All other alpha emitting radionuclides	10^{-5}	22

Table 10-2

Package Shipping Label	Label Image	Maximum permissible limit for package external surface radiation level (mrem/hr)	Maximum permissible limit for radiation level at 1 meter (mrem/hr)
Radioactive – White I		0.5	0.05
Radioactive – Yellow II		50	1
Radioactive – Yellow III		200	10
Radioactive – Yellow III (shipped under exclusive use provisions)		1000	>10

**NOTE: Current Type A quantity limits can be found in 49 CFR 173.435, Table of A1 and A2 values for radionuclides.

Section 11. Storage and Security of Radioactive Materials

Radioactive material shall be stored in a manner that:

a. Provides adequate radiation shielding such that:
   - In an uncontrolled area, the radiation levels are within the limits as set forth in Section 7 of this manual
   - In a controlled area, the occupational dose received from stored activity is less than 10% of the specified dose levels as set forth in Section 7 of this manual
b. Provides adequate protection against fire, explosion, or flooding
c. Provides adequate protection against accidental breakage of primary storage containers
d. Provides adequate protection against unauthorized use or removal

Radioisotopes shall not be left unattended in places where unauthorized persons may handle them or take them without realizing that they are radioactive.

Section 12. Unsealed Source Contamination Surveys

Contamination surveys must be conducted periodically in and around areas where unsealed radioactive material is used. These surveys are an essential part of contamination control to prevent the unnecessary spread of contamination to personnel, equipment, and work areas. Routine documentation of contamination levels can also help to simplify the decommissioning process when a radiation lab is released to non-radiation uses.

Table 12-1 specifies acceptable removable contamination limits for unsealed source use areas, equipment, etc. The values specified are maximum values and the actual contamination levels must also be maintained "As Low As Reasonably Achievable" (ALARA). In certain cases, the RSO may determine an acceptable contamination level specifically for a given use location and isotope using the most current version of RESRAD-BUILD which was developed under the joint sponsorship of the Department of Energy and Nuclear Regulatory Commission for site-specific dose assessment of residual radioactivity for decommissioning.

Table 12-1
Acceptable Removable Surface Contamination Levels

Contaminant	Acceptable Removable Contamination Levels (dpm/100 cm^2)
Beta or gamma emitter	1000
Natural Uranium, ^{235}U, ^{238}U and associated decay products	1000
Note: This table is adapted from Table I of NRC Regulatory Guide 1.86.	

12.1 Contamination Survey Frequency

12.1.1 Daily Meter Surveys

Each day an unsealed source is used, a survey must be conducted using instrumentation appropriate to the isotope used. A thin window GM probe survey meter (e.g., pancake or end-window) is appropriate for most alpha, beta, and gamma emitters with the exception of ^{3}H. A wipe test analyzed on a liquid scintillation analyzer is the only acceptable survey method for ^{3}H. The daily survey is conducted to see if any locations have gross contamination. Contamination is considered present if the survey reveals count rates at twice the background count rate. Only count rate data for each location need be recorded for the daily surveys.

12.1.2 Weekly Wipe Test Surveys

In addition to the daily surveys required by Section 12.1.1, weekly wipe test surveys are required when a radioisotope is used in an activity exceeding 250 μCi per week. The wipe test survey should include areas most likely to have contamination. In addition, any location that was identified in the daily survey as contaminated must be included in the wipe test survey. If a wipe test result reveal contamination in excess of Table 12-1 values, decontamination is required. The wipe test survey data must be recorded in cpm, dpm and dpm/100 cm^2.

Surveys for gamma contamination shall additionally quantify the dose rate. The gamma dose rate survey shall be conducted with an appropriate survey meter calibrated to read in mR/hr. The dose rate shall be kept below 0.5 mR/hr.

12.1.3 Monthly Wipe Test Surveys

In addition to the daily surveys required by Section 12.1.1, monthly wipe test surveys are required when a radioisotope is used in an activity less than 250 μCi per week. The wipe test survey should include areas most likely to have contamination. In addition, any location that was identified in the daily survey as contaminated must be included in the wipe test survey. If a wipe test result reveals contamination in excess of Table 12-1 values, decontamination is required. The wipe test survey data must be recorded in cpm, dpm and dpm/100 cm^2.

Surveys for gamma contamination shall additionally quantify the dose rate. The gamma dose rate survey shall be conducted with an appropriate survey meter calibrated to read in mR/hr. The dose rate shall be kept below 0.5 mR/hr.

12.1.4 Contamination Survey Frequency Notes

The activity limits that determine whether weekly or monthly wipe test surveys are required may be reduced below the 250 μCi limit by the RSO for certain isotopes (e.g., I-125 or I-131).

Appendix J contains a listing by department of currently available survey meters and other survey equipment.

12.2 Common Contamination Survey Locations

The following are typical survey locations:

- Bottom of shoes, lab coats, hands
- Floor at entrance to work area
- Door handle at entrance to work area
- Work area surfaces
- Floor in front of work area
- Lab sink
- Drawer and cabinet handles near work area
- Equipment used (pipettes, centrifuges, etc.)
- Waste storage container lid handles
- If work is conducted in a fume hood surveys shall include
    - Floor in front of fume hood
    - Fume hood apron
    - Fume hood sash handle
    - Work surface in fume hood
- Other locations not listed that are possible contamination locations.

12.3 Wipe Test Contamination Limits

If the measured contamination level determined with a wipe test is above the value indicated in Table 12-1, decontaminate and re-survey the location. Document each decontamination and re-survey to reduce the measured contamination levels below the specified limits. Please remember that contamination levels need to be kept as low as possible below the maximum levels indicated in the tables.

12.4 Survey Documentation

A permanent record must be kept of all survey results, including negative results. Use the form in Appendix K to record the survey results. You may create your own form provided it documents the same information

as that in Appendix K. Any form used to document the surveys shall include the following information.

- Room number, survey date, and identification of survey equipment used, including the serial number and pertinent counting efficiencies.
- Name of person conducting the survey.
- A drawing of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.
- Description of wipe test or scan survey locations
- Detected contamination levels (in units of cpm for meter scans and in units of dpm/100 cm^2 for wipe tests), keyed to locations on the drawing.
- Measured exposure rates (for gamma-emitting isotopes only), keyed to locations on the drawing.
- Identification of survey locations that exceed contamination levels or exposure rates.
- Corrective action taken in the case of contamination or excessive exposure rates, reduced contamination levels or exposure rate after corrective action, and any appropriate comments.

12.5 Notes

- A Technical Instruction document for the execution of contamination surveys for beta-emitting isotopes is available from the RSO.
- Surface contamination of work areas and equipment can be minimized by paying close attention to lab hygiene. Remember to use plastic-backed absorbent bench paper instead of working directly on an uncovered surface. Change your protective gloves often and always before you handle items that you don't want contaminated (e.g., the radiation survey meter).
- dpm (disintegrations per minute) = cpm (counts per minute) / counter efficiency

Section 13. Transportation of Radioactive Materials

The transportation of radioactive material can be divided into roughly three categories. These are transportation of licensed radioactive material, transportation of license-exempt radioactive material by third party vendor, and transportation of license-exempt radioactive material by WKU employee.

The transportation of licensed radioactive material must comply with 902 KAR 100:070 and the Department of Transportation (DOT) regulations, in 49 CFR. The transportation of license-exempt radioactive material is not specifically addressed by 902 KAR 100. However, license exemption by KY radiation control regulations does not necessarily equate to exemption from the regulations issued by DOT for transportation purposes. The DOT exemption activity limits for the applicability of 49 CFR are different than the activity limits that define license exemption according to 902 KAR 100. The following sections define general requirements for each of the categories defined above.

Regardless of category, written approval must be obtained from the RSO prior to the transportation of any radioactive material. Your request for approval may be submitted in a e-mail detailing which source(s) is(are) to be transported, the destination, and when the source will be returned.

13.1 Transportation of Licensed Radioactive Material

Licensed radioactive material, for transportation purposes, may end up being classified as a limited quantity, excepted shipment, Radioactive-White I, Radioactive-Yellow II, or Radioactive-Yellow III. The classification depends mostly upon the activity of the material shipped, measured package surface dose rates, and measured dose rates at 1 meter from the package surface (this is referred to as the Transport Index or TI). Each classification has specific requirements that may include labeling, marking, shipping documentation, tamper evident seals, placards, emergency response information, DOT certified packaging, loading instructions, etc.

If you participate in any activities that affect the transportation of a licensed radioactive material, you must have current DOT Hazmat training. These activities include packing, labeling, marking, shipping document preparation, loading or unloading packages, or driving the transportation vehicle. Current DOT Hazmat training is documented training received within the past three years and includes:

- General awareness and function specific training
- Security awareness training
- Safety training (e.g., WKU-provided radiation safety training)

Note: Any licensed radioactive material shipment that requires the vehicle to be placarded, such as the shipment of a package labeled Radioactive-Yellow III, must be transported only by a qualified third-party vendor. WKU personnel may not drive a placarded vehicle containing this type of package.

13.2 Transportation of License-Exempt Radioactive Material via Third Party

The requirements for the transportation of licensed radioactive material also apply to shipments of license-exempt radioactive material via FedEx, UPS, Roadway, Overnight, etc.

13.3 Transportation of License-Exempt Radioactive Material via WKU Employee

Institutions such as government agencies and state universities, in general, are not held to the hazardous materials regulations (HMR) in 49 CFR when the transportation is conducted by an employee(s) of that institution for institution-related business. This has been clearly documented in interpretation letters written by the DOT (contact the RSO for details). Simply stated WKU is not held to the HMR if a WKU employee is driving (transporting) a hazardous material for WKU business. This does not hold for licensed radioactive

material transportation as 902 KAR 100 specifically states that licensed radioactive materials shall be transported according to 49 CFR regardless of any other exemption.

Since 902 KAR 100 is silent on this issue for license-exempt radioactive material, WKU applies the DOT exemption from the HMR described above.

13.4 Other Transportation Notes

Please contact the RSO for Standard Operating Procedures for the preparation and transportation of specific radioactive materials. If you require RSO assistance in the preparation of a radioactive material for transportation, please request that assistance at least 48 hours prior to the date you need the material to be shipped.

If the purpose of the radioactive material transportation is for use at a location not currently approved by the WKU Radioactive Material License, a request for reciprocity or a license transfer of materials may be required. Section 14 of this manual addresses the license transfer of radioactive materials. Section 15 addresses reciprocity.

Section 14. Transfer of Radioactive Material

14.1 On-Campus Transfers

On-campus transfers of radioactive material are only permitted between Authorized Users. Transfer recipients must be currently licensed for the use location, radionuclide, chemical form and quantity of radioactive material they wish to receive. Prior to the transfer, complete and submit an "On-Campus Transfer of Radioactive Material" form to the RSO, located in Appendix L. This form serves to document the exchange of inventory between the Authorized Users. Licensed radioactive material can be transferred in a WKU motor vehicle if applicable DOT regulations are followed. Please refer to Section 13 for details. If the material is not going to be moved to the transfer location by motor vehicle, please use these common sense guidelines when moving the material.

1. Carry unsealed solutions in the original stock vials when possible. When this is not possible, carry the solution(s) in a durable container. If the radioactive liquid is transported in a breakable container, it must be surrounded by enough absorbent material to readily soak up all the radioactive liquid.
2. Carry sources in an appropriately shielded container such that dose rates are as low as reasonably achievable.
3. Attach an appropriate radioactive material label reading "Caution Radioactive Material" to the outside of the container when the quantity being transferred exceeds the values indicated in Section 6 of this manual.
4. To lessen the chance of mishaps and to reduce exposure to members of the general population, movement of radioactivity should be restricted to periods when traffic in corridors and on stairs is light. Make transit time short. Avoid unnecessary stops along the way. Never leave radioactivity unattended in any place but an approved locked storage area. Also do not store radioactivity anywhere but authorized radiation laboratories and storage areas.
5. Check the container for contamination after removal of the source.
6. If a spill should occur outside the laboratory, contact the RSO and do not leave the area unattended unless it is necessary to render immediate emergency attention to personnel involved in the spill. Post a guard and restrict access to the contaminated area until such time as compliance with guidelines outlined in Section 16, "Emergencies," can be established.

14.2 Off-Campus Transfers

Off-campus transfers are allowed only to authorized vendors and/or organizations licensed to possess the radioactive material to be transferred. If you wish to transfer a licensed radioactive material to another organization (including transfers to a vendor for repair), please fill out and submit the form in Appendix M to the RSO prior to the transfer. The RSO will contact the organization to obtain documentation, where necessary, verifying its authorization to receive the licensed material. Please refer to Section 13 for details on transportation requirements.

Section 15. Reciprocity

Reciprocal recognition, or reciprocity, occurs when a radiation control agency from another state gives WKU approval to temporarily operate under its Kentucky Radioactive Material License in its state. If the intended use location is under the jurisdiction of the Nuclear Regulatory Commission (such as a Federal facility in Kentucky or another state) then the reciprocity application is submitted to the NRC. If the location is under the jurisdiction of an Agreement State, then the reciprocity application is submitted to that state's radiation control program.

If you need to apply for reciprocity for one or more of your licensed radioactive materials, please submit a Radiation Work Permit (found in Appendix D) to the RSO. Upon receipt of this RWP, the RSO will contact the appropriate radiation control agency to initiate the application for reciprocal recognition. The RSO will also forward the Radiation Work Permit to the WKU Radiation Safety Committee for consideration.

Section 16. Radioactive Material Emergency Guidelines

16.1 Emergency Procedures

Each radioactive material user must be ready and equipped to handle a radiological spill or emergency. Information and knowledge concerning the type of radioactive materials being used, the availability of adequate spill response supplies, and knowing when and who to call for assistance are all critical elements needed to effectively respond to any type of radioactive material incident. The RSO will initially provide a stocked spill kit for each lab that uses open sources of radioactivity. Each unsealed source use lab is required to have a stocked spill kit. Replenishment of the supplies in the spill kit is the responsibility of the department or laboratory.

It is the responsibility of the Authorized User to ensure that his/her personnel are trained and periodically practice spill or emergency response scenarios. The RSO is available to provide guidance, training, and support regarding spill and emergency response strategies and management.

In the case of a spill, the individuals causing the spill will be required to perform the major portion of the decontamination. The RSO will provide assistance as necessary.

At the conclusion of any spill cleanup or emergency, the individuals involved shall cooperate fully with the RSO in preparing whatever reports are required by the Federal, State, and local authorities.

Emergency Procedure Postings are Located in Appendices P and Q

These appendices provide radiation emergency procedures for sealed and unsealed source use areas, respectively. The appropriate procedure shall be posted in each licensed radioactive material use location or area.

16.2 Notification of Incidents

16.2.1 Immediate Notification

If any of the following occurs, immediately notify the RSO. The RSO will, in turn, immediately contact the KY Radiation Health Branch.

An event involving radioactive material possessed by WKU that may have caused, or threatens to cause, one (1) or more of the following conditions:

a. An individual may receive:
   - a total effective dose equivalent of twenty-five (25) rems (0.25 Sv) or more;
   - an eye dose equivalent of seventy-five (75) rems (0.75 Sv) or more; or
   - A shallow-dose equivalent to the skin or extremities of 250 rads (two and five-tenths (2.5) Gy) or more;

b. The release of radioactive material, inside or outside of a restricted area; so that, had an individual been present for twenty-four (24) hours, the individual may have received an intake five (5) times the occupational annual limit on intake. The provisions of this paragraph shall not apply to locations in which personnel are not normally stationed during routine operations, such as in hot-cells or process enclosure;

c. A loss of one (1) working week or more of the operation of facilities affected; or

d. Damage to property in excess of $200,000.

16.2.2 Twenty-four (24) hour notification

The RSO must within twenty-four (24) hours of discovery of the event, report an event involving loss of control of licensed or registered source of radiation possessed by WKU that may have caused, or shall threaten to cause, one (1) or more of the following conditions:

a. An individual to receive, in a period of twenty-four (24) hours:
   - A total effective dose equivalent exceeding five (5) rems (0.05 Sv);
   - An eye dose equivalent exceeding fifteen (15) rems (0.15 Sv); or
   - A shallow-dose equivalent to the skin or extremities exceeding fifty (50) rems (five-tenths (0.5) Sv);

b. The release of radioactive material, inside or outside of a restricted area; so that, had an individual been present for twenty-four (24) hours, the individual may have received an intake in excess of one (1) occupational annual limit on intake. The provisions of this paragraph shall not apply to locations in which personnel are not normally stationed during routine operations, such as in hot-cells or process enclosures;

c. A loss of one (1) day or more of the operation of facilities affected; or

d. Damage to property in excess of $2,000.

16.2.3 Incident Notification Methods

The RSO, with the assistance of the applicable AU(s) and/or SU(s), shall prepare and file a report with the KY Radiation Health Branch so that names of individuals who have received exposure to radiation or radioactive material are stated in a separate and detachable part of the report.

a. The RSO shall make reports to the cabinet by:
   - Telephone;
   - Telegram;
   - Mailgram; or
   - Facsimile.

Section 17. Radioactive Waste

All radioactive material which comes into WKU must be accounted for. It is imperative that accurate records of radioactive material use and disposal be kept. To provide accountability for the use and disposal of unsealed radioactive material, there are specific records that shall be kept by the AU and/or SU. These records are the **Radioisotope Use/Disposal Record** and the **Hot Sink Disposal Record** which are located in **Appendices H and I**, respectively.

All radioactive material must be disposed of in accordance with 902 KAR 100:021, the provisions in this manual, and any associated technical guidance issued by the RSO and/or the RSC. The final disposition of all radioactive waste, except aqueous radioactive waste disposed via sanitary sewer, must be by the RSO. Unless otherwise specified, the RSO will arrange the final removal, transportation, and disposal of radioactive waste through a licensed radioactive waste broker. Where it is not practical to store waste in the radiation lab generating the waste, the RSO will remove the waste to storage in Thompson Complex Center Wing Room 21.

In an effort to reduce the cost of disposal, do not put uncontaminated waste in containers specifically designated for radioactive waste. On-site incineration of radioactive waste shall not be done.

17.1 Disposal in the Sanitary Sewer ("Hot Sinks")

Water soluble or dispersible waste may be disposed of in the sanitary sewer only if the Authorized User was given approval by the RSC in the Radiation Work Permit. The Authorized User may dispose of licensed or license-exempt quantities of radioactive material in a hot sink under the following conditions:

a. The material shall be readily soluble, or shall be readily dispersible biological material, in water;
b. The quantity of licensed or other radioactive material that the licensee released into the sewer in one (1) month, divided by the average monthly volume of water released into the sewer by the licensee, shall not exceed the concentration in 902 KAR 100:019, Section 44, Table III. As a conservative measure the maximum allowed disposal activity will be restricted to 10% of the calculated limit. The RSO will post a document at each hot sink that indicates the maximum calculated activity of radioactive material that can be disposed in any given month or year.
c. For the release of more than one (1) radionuclide, the following conditions shall be satisfied:
    - The licensee shall determine the fraction of the limit in 902 KAR 100:019, Section 44, Table III, represented by discharges into the sanitary sewerage by dividing the actual monthly average concentration of each radionuclide released by the licensee into the sewer by the concentration of that radionuclide in 902 KAR 100:019, Section 44, Table III; and
    - The sum of the fractions for each radionuclide shall not exceed unity; and
    - The total quantity of licensed and other radioactive material that the licensee releases into the sewerage system in a year shall not exceed five (5) curies (185 GBq) of hydrogen-3, one (1) curie (37 GBq) of carbon-14, and one (1) curie of other radioactive materials combined.
d. The solution disposed shall not exhibit characteristics of EPA-defined hazardous waste.
e. Use only the sink designated in your Radiation Work Permit.
f. Always keep amounts below the approved maximum.
g. Dilute the waste several times and if possible, pour the waste directly into the drain. Flush the sink thoroughly afterward. Use the sink for disposal of uncontaminated waste also.
h. If the drain in the sink becomes plugged or begins to leak, prevent others from using the sink and notify the RSO immediately.
i. Make the appropriate entry in the **Radioisotope Use/Disposal Record** and the **Hot Sink Disposal Record**.

17.2 Liquid Radioactive Waste and/or Liquid Mixed Waste

All liquid waste not approved for disposal in the sanitary sewer must be held in storage until proper disposal is arranged with a radioactive waste broker.

a. Make every effort to avoid generating mixed waste. It is extremely expensive to dispose.
b. Use a properly labeled polyethylene, Nalgene, or similar container that is chemically compatible with the waste. Carboys are good for storing moderate amounts of liquid waste. Be sure to keep the container tightly closed.
c. Use separate storage containers for liquid radioactive waste and liquid mixed waste (i.e., waste that is also considered chemically hazardous according to the regulations of the US EPA).
d. If there will be large volumes (> 10 gallons or 40 L) of liquid radioactive waste generated, call the RSO in advance to arrange for the acquisition of a DOT approved liquid waste drum or drums suitable for the volume of waste that will be generated.
e. Empty all of the liquid into this container.
f. Make the appropriate entry in the **Radioisotope Use/Disposal Record**.
g. Keep the waste container in a secure place as designated in the Radiation Work Permit.
h. Liquid waste containers must also be stored in a secondary containment.
i. Close any full waste containers.
j. Properly label the waste container with the radioactive waste tag pictured in Section 17.7 prior to RSO pickup. Contact the RSO to obtain waste tags.
k. Contact the RSO when you need the waste removed from your work area.

17.3 Solid Radioactive Waste and/or Solid Mixed Waste

A properly labeled waste container (typically a yellow bucket or garbage can) will be placed in your primary work areas for the disposal of dry (solid) radioactive waste or solid mixed waste. Solid waste is typically comprised of gloves, disposable lab coats, paper towels, glass or plastic labware, pipette tips, etc.. No item of solid waste can contain more than 5 ml of liquid. The typical label used to identify a radioactive waste container is found in Section 17.7.

a. Make every effort to avoid generating mixed waste. It is extremely expensive to dispose.
b. If large volumes or masses of solid waste will be generated, contact the RSO in advance to arrange for the acquisition of a DOT approved solid waste drum (typically a 55-gallon steel drum).
c. Put any powdered material in a plastic container and seal it prior to disposal.
d. Put hypodermic needles, glass and other sharp objects inside shatterproof protection containers prior to disposal.
e. Unless authorized by the RSO, do not put more than 25 pounds of material into a collection container.
f. Close any full waste bags and properly label with the radioactive waste tag pictured in Section 17.7 prior to RSO pickup. Contact the RSO to obtain waste tags.
g. Contact the RSO when you need the waste removed from your work area.

17.4 Sealed Source Disposal

Sealed sources that are no longer needed must be disposed:

a. by returning the source to the vendor
b. through a properly licensed radioactive waste broker
c. by license transfer to an authorized specific licensee

Contact the RSO when you have a sealed source that you wish to dispose.

17.5 Decay-In-Storage

Departments possessing adequately shielded facilities may hold radioactive material with physical half-lives less than or equal to 120 days for decay-in-storage before disposal as ordinary trash, provided the following conditions are met:

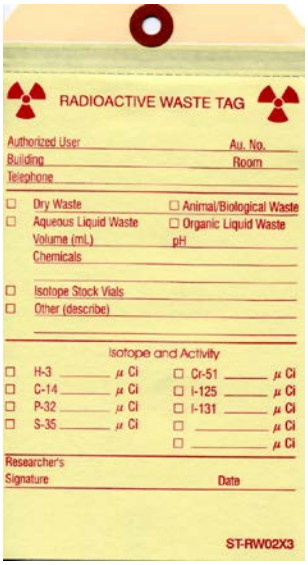
a. When the waste bag in a waste storage container is full, it should be sealed and labeled with the appropriate identifying information. A radioactive waste tag attached to the bag with a twist tie is recommended for this and can be obtained from the Radiation Safety Officer. An image of the waste tag appears in Section 17.7.
b. Liquid and solid waste held for decay-in-storage must be stored separately from non-decay in storage waste.
c. All radiation labels are removed or obliterated
d. The material, during storage, is stored in suitable, well-marked containers that provide adequate shielding for the emitted radiation.
e. The radioactive material is held for decay a minimum of 10 half-lives
f. Prior to disposal as ordinary trash, each container must be monitored as follows:
    - Check the radiation survey meter for proper operation
    - Survey the container in a low background area without shielding around the container
    - Monitor all surfaces of the container
    - Discard the contents as ordinary trash only if the surveys of the contents indicate no residual radioactivity, i.e., surface readings are indistinguishable from background
g. If the surveys indicate residual radioactivity, return the container to the decay-in-storage location for additional half-lives to allow further decay.

A record of the decay-in-storage disposal must be maintained that includes the date of the disposal, the date on which the radioactive material was placed in storage, the radionuclide(s) disposed, the model and serial number of the survey instrument used, the background radiation exposure rate, the radiation exposure rate measured at the surface of each waste container, and the name of the individual who performed the disposal.

17.6 Disposal Without Regard to Radioactivity

Liquid scintillation counting media containing 0.05 µCi or less of hydrogen-3 (tritium), carbon-14, or iodine-125 per gram of the medium may be disposed without regard to radioactivity. The liquid scintillation media cannot, however, be disposed down the sink or in the trash. Contact the RSO for guidance on submitting a regulated waste pickup request to the Department of Environmental Health & Safety.

17.7 Radioactive Waste Container Labels and Waste Tags



Radioactive Waste Tag

Typical Radioactive Waste Storage Container Label

Section 18. Decommissioning Radioactive Material Areas

Prior to the release of a radioactive material use/storage area for unrestricted use, that area must be decommissioned. Decommissioning initially involves the compilation of a historical site assessment that summarizes the radioisotope use/storage in a given area. In very simple cases historical documentation, such as contamination surveys, possession records, leak test records, etc. may be all that is required for the KY Radiation Health Branch to recognize and approve that a given location is decommissioned.

What is more often needed in addition to the historical site assessment and documentation is a final status survey that confirms residual radioactivity (if any) will not cause any individual to receive more than 25 mrem/year from that residual activity. This is the stated dose-based release criterion per 902 KAR 100:042. There may be simple final status surveys that can be handled by the RSO and the Authorized User. In other cases, the RSO will obtain a quotation from a vendor to conduct a MARSSIM-compliant survey and provide a final status report.

It is the Authorized User's responsibility to request the proper removal of all radioactive sources and radioactive waste prior to decommissioning. Radiation postings, warning signs, etc. shall not be removed prior to the completion of the decommissioning process.

Decommissioning is considered complete only after the final status survey report has been submitted to, and approved by, the KY Radiation Health Branch via a license amendment request.

Please contact the RSO if you have a radioactive materials use area that you wish to release to unrestricted use.