Boston College Environmental Health and Safety

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APPENDICES

Appendix A. Glossary of Terms

ABBREVIATIONS: RSC - Radiation Safety Committee; RSO - Radiation Safety Officer; RSM - Radiation Safety Manual; RST - Radiation Safety Technician.

ABSORPTION: The phenomenon by which radiation imparts some or all of its energy to any material through which it passes.

ALARA: (As Low as Reasonably Achievable) Making every reasonable effort to maintain exposures to radiation as far below the NRC specified dose limits as is practicle consistent with the purpose for which the licensed activity undertaken.

ALI: (Annual Limit on Intake) The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year that would result in a committed effective dose equivalent of 5 rem (0.05Sv) or a committed dose equivalent of 50 rem (0.5Sv) to any individual organ or tissue.

ALPHA PARTICLE: A strongly ionizing particle emitted from the nucleus during radioactive decay having a mass and charge equal in magnitude to a helium nucleus, consisting of 2 protons and 2 neutrons with a double positive charge.

ANNIHILATION (Electron): An interaction between a positive and negative electron; their energy, including rest energy, being converted into electromagnetic radiation (annihilation radiation).

ATOM: Smallest particle of an element which is capable of entering into a chemical reaction.

AUTORADIOGRAPH: Record of radiation from radioactive material in an object, made by placing the object in close proximity to a photographic emulsion.

BACKGROUND RADIATION: Ionizing radiation arising from radioactive materials other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in the building material itself, etc.

BEQUEREL (Bq): The SI unit of activity in disintegrations per second (s-1). (1 Ci=3.7x1010 Bq).

BETA PARTICLE: Charged particles emitted from the nucleus of an atom, having a mass equal in magnitude to that of the electron, and a single positive or negative charge.

BREMSSTRAHLUNG: Electromagnetic (x-ray) radiation associated with the deceleration of charged particles passing through matter. Usually associated with energetic beta emitters, e.g. phosphorus-32.

CALIBRATION: Determination of accuracy or variation from standard of a measuring instrument to ascertain necessary correction factors.

CARRIER FREE: An adjective applied to one or more radionulcides of an element in minute quantity, essentially undiluted with stable isotope carrier.

COMMITTED DOSE EQUIVALENT (HT,50): The dose equivalent to tissue or organs of reference (T) that will be received from an intake of radioactive material by an individual during the 50 year period following the intake.

COMMITTED EFFECTIVE DOSE EQUIVALENT (HE,50): The sum of the products of the weighting factors applicable to the body organs or tissues that are irradiated and the committed dose equivalent to the tissues or organs.

CONTAMINATION, RADIOACTIVE: Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful. Contaminations may negate the validity of an experiment, as well as being a source of internal or external radiation exposure.

COUNT (Radiation Measurements): The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse. (See Efficiency).

CRITICAL ORGAN: The organ or tissue, the irradiation of which will result in the greatest hazard to health of the individual or his descendants.

CURIE: The quantity of any radioactive material in which the number of disintegrations is 3.7000 x

1010 per second. Abbreviated Ci. Millicurie: One-Thousandth of a curie (3.7 x 107 disintegrations per second or 2.22 x 10 12 disintegrations per minute). Abbreviated mCi. (See Bequerel).

DAC: (Derived Air Concentration) The concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work, results in an intake of one ALI

DECAY, RADIOACTIVE: Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

DEEP DOSE EQUIVALENT (Hd): External whole body exposure, the dose equivalent at a tissue depth of 1 cm (1000 mg/cm2).

DOSE: A general term denoting the quantity of radiation or energy absorbed in a specified mass. For special purposes it must be appropriately qualified, e.g. absorbed dose.

DOSE, ABSORBED: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad (62.4 x 106 MeV/g or the gray (1 J/kg).

DOSE EQUIVALENT: A quantity used in radiation protection expressing all radiation on a common scale for calculating the effective absorbed dose. The unit of dose equivalent is the rem, which is numerically equal to the absorbed dose in rads multiplied by certain modifying factors such as the quality factor, the distribution factor, etc. (See Sievert)

EFFICIENCY (Counters): A measure of the probability that a count will be recorded when radiation is incident on a detector. Usage varies considerably so it is well to make sure which factors (window, transmission, sensitive volume, energy dependence, etc.) are included in a given case.

ELECTRON: Negatively charged elementary particle which is a constituent of every neutral atom. Its quantity of negative charge equals 1.6 x 10-19 coulombs. Its mass is .000549 atomic mass units.

ELECTRON CAPTURE: A mode of radioactive decay involving the capture of an orbital electron by its nucleus. Capture from a particular electron shell is designated a "K-electron capture," "L-electron capture," etc.

ELECTRON VOLT: A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt. Abbreviated eV. Larger multiple units of the electron volt frequently used are: keV for thousand electron volts, MeV for million electron volts and GeV for billion election volts.

ERYTHEMA: An abnormal reddening of the skin due to distention of the capillaries with blood. It can be caused by many different agents - heat, drugs, ultra-violet rays, ionizing radiation.

FILM BADGE: A packet of photographic film used for the approximate measurement of external radiation exposure for personnel monitoring purposes. The badge may contain one or more films of differing sensitivity, and it may contain filters which shield parts of the film from certain types of radiation.

GAMMA RAY: Very penetrating electromagnetic radiation of nuclear origin. Except for origin, identical to x-ray. (See Photon)

GEIGER-MUELLER (GM) COUNTER: Highly sensitive gas-filled detector and associated circuitry used for radiation detection and measurement. A high operating potential amplifies the primary ion pairs to allow a single radioactive particle or photon entering the chamber to be detected.

GENETIC EFFECT OF RADIATION: Inheritable changes, chiefly mutations, produced by the absorption of ionizing radiations. On the basis of present knowledge these effects are purely additive, and there is no threshold or recovery.

GRAY (Gy): The SI unit of absorbed dose equal to 1 j/kg or 100 rads.

HALF-LIFE, BIOLOGICAL: The time required for the body to eliminate one-half of an administered dose of any substance by the regular processes of elimination.

HALF-LIFE, EFFECTIVE: Time required for a radioactive nuclide in a system to be diminished 50% as a result of the combined action of radioactive decay and biological elimination. Effective half-life= (Biological half-life x Radioactive half-life) / (Biological half-life + Radioactive half-life)

HALF-LIFE, RADIOACTIVE: Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

HALF VALUE LAYER (Half thickness): The thickness of any specified material necessary to reduce the intensity of an x-ray or gamma ray beam to one-half its original value.

HEALTH PHYSICS: A term in common use for that branch of radiological science dealing with the protection of personnel from harmful effects of ionizing radiation.

INVERSE SQUARE LAW: The intensity of radiation at any distance from a point source varies inversely as the square of the distance. For example, if the radiation exposure is 100 mRem/hr at 1 inch from the source, the exposure will be 0.01 R/hr at 100 inches.

INVESTIGATION LEVEL (of a radioisotope): That amount of radioactive material which, if taken into the body in one event, would result in a total integrated dose of 10% of the maximum quarterly allowable dose to the whole body or critical organ.

ION: Atomic particles, atom, or chemical radical bearing an electrical charge, either negative or positive.

IONIZATION: The process by which a neutral atom or molecule acquires either a positive or a negative charge.

IONIZATION CHAMBER: An instrument designed to measure the quantity of ionizing radiation in terms of the current flow between two electrodes associated with ions produced within a defined volume. The current is directly related to type and quantity of energy penetrating the chamber. Because of chamber size limitations and low currents, ionization chambers are not usually used to measure low levels of radiation.

IONIZATION, SPECIFIC: The number of ion pairs per unit length of path of ionizing radiation in a medium, e.g. per centimeter of air or per micron of tissue.

IONIZING RADIATION: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

LABELLED COMPOUND: A compound consisting, in part, of labelled molecules or atoms. By radioactivity observations the compound or its fragments may be followed through physical, chemical or biological processes.

LET (Linear Energy Transfer): Used in radiation biology and radiation effects studies to describe the linear rate of energy absorption in the absorbing medium. It is usually expressed in units of keV/micron. Generally, the higher the rate of LET of the radiation, the more effective it is in damaging the organism.

MILLIROENTGEN (mR): A submultiple or roentgen equal to one one-thousandth (1/1000th) of a roentgen. (See Roentgen)

MONITORING, RADIOLOGICAL: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region as a safety measure for purposes of health protection.

Area Monitoring: Routine monitoring for contamination of any particular area, building, room, or equipment.

Personnel Monitoring: Monitoring any part of an individual, breath, execretion, or any part of the clothing. (See Radiological Survey)

NEUTRON: Elementary particles with a mass approximately the same as that of a proton and electrically neutral. It transfers energy when it collides with an atomic nucleus.

NUCLIDE: A species of atom characterized by its mass number, atomic number, and energy state of its nucleus.

OCCUPATIONAL DOSE: The dose received by an individual in a restricted area or in the course of employment in which the assigned duties involve exposure to radiation and radioactive materials from licensed and unlicensed sources. Occupational dose does not include dose from background radiation, as a patient from medical practices, or as a member of the general public.

PLANNED SPECIAL EXPOSURE: An infrequent exposure to radiation, seperate from and in addition to the annual dose. Planned Special Exposures must be approved by the NRC and the RSC.

PHOTON: A quantity of electromagnetic energy (E) whose value is the product of its frequency (f) and Planck's constant (h). The equation is: $E=hf$.

PROTECTIVE BARRIERS: Barriers of radiation absorbing material, such as lead, concrete, plaster, and plastic, that are used to reduce radiation exposure.

Protective Barriers, Primary: Barriers sufficient to attenuate the useful beam to the required degree.

Protective Barriers, Secondary: Barriers sufficient to attenuate stray or scattered radiation to the required degree.

RAD: The absorbing dose, or amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material, equivalent to .01 J/kg. (See Gray)

RADIATION: 1. The emission and propagation of energy through space or through a material medium in the form of waves; for instance, the emission and propagation of electromagnetic waves, or of sound and elastic waves. 2. The energy propagated through a material medium as waves; for example, energy in the form of electromagnetic waves or or elastic waves. The term "radiation" or "radiant energy," when unqualified, usually refers to electromagnetic radiation. Such radiation commonly is classified according to frequency as Hertzian, infrared, visible (light), ultraviolet, x-ray, and gamma ray. 3. By extension, corpuscular emissions, such as alpha and beta radiation, or rays of mixed or unknown type, as cosmic radiation.

RADIOLOGICAL SURVEY: Evaluation of the radiation hazards incident to the production, use or existence of radioactive materials or other sources of radiation under a specific set of conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and a sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible change in materials or equipment.

RADIOACTIVITY: The property of certain nuclides of spontaneously emitting particles, or gamma radiation; or of emitting x-radiation following orbital electron capture, or undergoing spontaneous fission.

RADIONUCLIDE: A nuclide with an unstable ratio of neutrons to protons, placing the nucleus in a state of stress. In an attempt to reorganize to a more stable state, it may undergo various types of rearrangement that involve the release of radiation.

RADIOTOXICITY: Term referring to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radioactive material introduced into the body.

RELATIVE BIOLOGICAL EFFECTIVENESS (RBE): For a particular living organism or part of an organism, the ratio of the absorbed dose of the radiation of interest that produces a specified biological effect to the absorbed dose of a reference radiation that produces the same biological effect.

REM: The special unit of dose equivalent. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the quality factor, distribution factor, and other necessary modifying factors. (See Sievert)

ROENTGEN (R): The special unit of radiation exposure in air. In 1962 the International Committee on Radiation Units (ICRU) defined exposure as "the quotient dQ by dm, where dQ is the sum of all the electrical charges on all the ions of one sign produced in air when all the electrons (negatrons and positrons), liberated by photons in a volume of air whose mass is dm, are completely stopped in air". 1R = 2.58 x 10-4 coulombs/kg.

SCINTILLATION COUNTER: A counter in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.

SHALLOW DOSE EQUIVALENT: The dose equivalent for external exposure of the skin or extremities measured at a tissue depth of 0.007 cm (7 mg/cm2) averaged over an area of 1 cm2.

SHIELDING MATERIAL: Any material which is used to absorb radiation and thus effectively reduce the intensity of radiation, and in some cases eliminate it. Lead, concrete, aluminum, water, and plastic are examples of commonly used shielding material.

SIEVERT (Sv): The SI unit of dose equivalent equal to 1 J/kg when modified by quality factors and uniformity of radiation. The Sv is expected to replace the rem.

SPECIFIC ACTIVITY: Total radioactivity of a given nuclide per unit mass or volume of a compound, element or radioactive nuclide.

STOCHASTIC EFFECTS: Health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear function of dose without threshold. Hereditary effects and cancers are stochastic effects.

THERMOLUMINESCENT DOSIMETER (TLD): A dosimeter made of certain crystalline materials which is capable of both storing a fraction of energy due to absorption of ionizing radiation and releasing this energy in the form of visible light when heated. The amount of light released can be used as a measure of radiation exposure to these crystals.

TOTAL EFFECTIVE DOSE EQUIVALENT: (TEDE) The sum of the deep dose equivalent for external exposure and the committed effective dose equivalent for internal exposure.

TRACER, ISOTOPIC: The isotope or nonnatural mixture of isotopes of an element which may be incorporated into a sample to make possible observation of the course of that element, alone or in combination, through a chemical, biological, or physical process. The observations may be made by measurement of radioactivity or of isotopic abundance.

X-RAYS: Penetrating electromagnetic radiation having wavelengths shorter than those of visible light. They are usually produced by bombarding a metallic target with fast electrons in a high vacuum. In the nuclear reactions it is customary to refer to photons originating in the nucleus as gamma rays, and those originating in the extranuclear part of the atom as x-rays.

Appendix B. General Rules for the Safe Use of Radioactive Material

1. Wear laboratory coats or other protective clothing at all times in areas where radioactive materials are used.

2. Wear disposable gloves at all times while handling radioactive materials.

3. Monitor hands, clothing and shoes for contamination after each procedure or before leaving the area. Survey area at the end of the day.

4. Do not eat, drink, smoke, or apply cosmetics in any area where radioactive material is stored or used.

5. Wear appropriate personnel monitoring devices at all times while in areas where radioactive materials are used or stored. These devices should be worn at the working level.

6. Wear finger badges when handling one millicurie or greater 32P or other energetic beta-emitters.

7. Dispose of radioactive waste only in specially designated receptacles.

8. Never pipette by mouth.

9. Confine radioactive solutions in covered containers plainly identified and labelled with name of compound, radionuclide, date, activity, and radiation level, if applicable.

10. Always transport radioactive materials in shielding containers and always use shielding when working with radiooactive materials in the lab.

RADIATION RULES OF THUMB AND HELPFUL INFORMATION

BETA PARTICLES

a. Beta particles of at least 70 keV energy are required to penetrate the nominal protective layer of the skin (7 mg/cm2 or 0.07 mm).

b. The average energy of a beta-ray spectrum is approximately one-third the maximum energy.

c. The range of beta particles in air is 12 ft/MeV. (Maximum range of 32P-beta is 1.71 MeV x 12 ft/MeV = 20 ft).

d. 1/4 inch of lucite will attenuate the air dose rate of 32P and other energetic beta particles by a factor of more than 200X.

e. The dose rate in rads per hour in a solution by a beta emitter is 1.12 EC/d, where E is the average beta energy per disintegration in MeV, C is the concentration in microcuries per cubic centimeter, and d is the density of the medium in grams per cubic centimeter. The dose rate at the surface of the solution is one-half the value given by this relation. (For 32P average energy of approximately 0.7 MeV, the dose rate from 1 µCi/cm3 (in water) is 1.48 rads/hr).

f. The surface dose rate through the nominal protective layer of the skin (7 mg/cm2) from a uniform thin deposition of 1 µCi/cm2 is about 9 rads/hour for energies above 0.6 MeV. Note that in a thin layer, the beta dose rate exceeds the gamma dose rate, for equal energies released, by about a factor of 100.

g. For a point source of beta radiation (neglecting self and air absorption) of known activity in millicuries (mCi), the dose rate (D) in rads per hour at 1 ft is given by the equation D=300 x (# Ci). This varies only slightly with beta energy. (Dose rate for 1 mCi 32P at 1 cm is approximately 300 rads/hour).

GAMMA RAYS

a. For a point source gamma emitter with energies between 0.07 and 4 MeV, the exposure rate in mR/hr ±20% at 1 foot is: 6 x mCi x E x n, where mCi is the number of millicuries, E, the energy in MeV; and n, the number of gammas per disintegration.

b. The dose rate to tissue in rads per hour in an infinite medium uniformly contaminated by a gamma emitter is 2.12 EC/d, where C is the number of microcuries per cubic centimeter, E is the average gamma energy per disintegration in MeV, and d is the density of the medium. At the surface of a large body, the dose rate is about half this.

c. Gamma and x-ray photons up to 2 MeV will be attenuated by at least a factor of 10 by 2 inches of lead.

Appendix C. Useful Tables

Table 1.

Airborne Contamination Limits for Common Radioisotopes	
Isotope	**ALI* in uCi**
14C	2x103
3H	8x104
35S	2x104
131I	5x101
125I	6x101
32P	9x102
45Ca	8x102
24Na	5x103
42K	5x103
51Cr	2x104
36Cl	2x103
99Tc	7x102

*ALI = Annual Limit on Intake (See Glossary of Terms for definition)

Table 2. Minimum Quantities Requiring Signs or Labels (Selected Radioisotopes)

Isotope	**Signs on Rooms* µCi**	**Labels** µCi**
14C	10,000	1000
3H (HTO, 3H20)	10,000	1,000
45Ca	1000	100
60Co	10	1
36Cl	100	10

51Cr	10,000	1,000
137Cs	100	10
64Cu, 55Fe	10,000	1000
59Fe	100	10
131I	10	1
125I	10	1
24Na, 32P	100	10
35S	1,000	100
90Sr	1	0.1
99Tc	1,000	100

*Signs are not required on rooms in cases where radioisotopes will be in the room for less than 8 hours provided that (1) the materials are constantly attended by an individual who will take necessary precautions to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations; (2) the room is under the authorized user's control.

Table 3. Maximum Concentrations of Radioisotopes Permissible for Sink Disposal

(Selected Radioisotopes)

(Soluble Forms Only)* Note that sink disposal log entries must not exceed these limits. (CFR 20.2003)

Isotope	**Maximum Daily Laboratory Limit µCi**
14c	100
3H	1000
125I	1
131I	1
32P	10
35P	100
35S	25
99Tc	50
103Ru	100
106Ru	10

Daily laboratory limits in µCi were calculated based on the "Monthly Average Concentration in µCi/ml" from Table 3, Appendix B, as well as requirements in Section 20.2003, 10 CFR, Part 20, Chapter 1 of NRC Rules and Regulations. Laboratory limits are based on a 500,000 gallon/day discharge from the campus, the number of laboratories and users using a particular isotope, and assumes that all laboratories are disposing of the maximum daily amount (listed above) 365 days/year.

* Only readily soluble (or readily dispersible biological) material can be sink disposed. See NRC

Information Notice 94-07, "Solubility Criteria for Liquid Effluent Releases to Sanitary Sewerage Under the Revised 10 CFR Part 20" which was distributed to all laboratories in January 1994 and is available from the RSO.

Dilute all isotopes for sink disposal as appropriate so that exposure limits from the diluent are below 2 mRem/hr.

Table 4. Acceptable Surface Contamination Levels.

Nuclides	**Average**	**Maximum**	**Removable**
Unat, 235U, 230U & decay products	5,000 dpm a/100 cm2	15,000 dpm a/100 cm2	1,000 dpm a/100 cm2
Transuranics, 226Ra,228Ra, 230Th, 228Th, 231Pa,227Ac, 125I, 129I	100 dpm/100 cm2	300 dpm/100 cm2	200 dpm/100 cm2
Th-nat, 232Th, 90Sr, 223Ra, 224Ra, 232U, 126I, 133I	1000 dpm/100 cm2	3000 dpm/100 cm2	200 dpm/100 cm2
b-g emitters (nuclides with decay modes other than a-emission or spontaneous fission) except 90Sr, U & transuranics.	5000 dpm b-g/100 cm2	15,000 dpm b-g/100 cm2	1000 dpm b-g/100 cm2

Notes:

1) Where surface contamination by both alph and beta-gamma emitting nuclides exists, the limits established should apply independently.

2) As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the cpm (counts per minute) observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

3) Measurements of average contamination should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

4) The maximum contamination level applies to an area of not more than 100 square cm.

5) The amount of removable radioactive material per 100 square cm of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known

efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionately and the entire surface should be wiped.

6) The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr. at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 mg/square cm of total absorber.

Table 5. Classification of Radionuclides

according to Relative Hazard Potential

Class 1

(very high toxicity)

90Sr + 90Y, *210Pb + 210Bi(Ra D + E), 210Po, 211At, *226Ra + 55% *daughter products, 227Ac, *228Th, *229Th, *230Th, *231Th, *233U, 238Pu, 239Pu, *241Am, 242Cm, 252Cf, plus other transuranic isotopes.

Class 2

(high toxicity)

Ca-45, *Ca-47, *Fe-59, *Co-60, *Sr-85, Sr-89, Y-91, *Ru-106 + Rh-106, *Cd-109, *Cd-115, *I-125, *I-131, *Ba-140 + *La-140, Ce-144 + *Pr-144, Sm-151, *Eu-152, *Eu-154, *Tm-170, *Hg-203, *Th-232, *natural thorium, *natural uranium.

Class 3

(moderate toxicity)

*Na-22, *Na-24, 32P, 33P, 35S, Cl-36, *K-42, *Sc-46, *Sc-47, *Sc-47,

*Sc-48, *V-48, *Mn-54, *Mn-56, Fe-55, *Co-57, *Co-58, Ni-59, Ni-63, *Cu-64, *Cu-67, *Zn-65, *Ga-67, Ga-68, *Ga-72, *As-74, *As-76, *Br-82, *Kr-85,

*Rb-84, *Rb-86, *Zr-95 + *Nb-95, *Nb-95, 99Mo*, 99Tc, *Rh-105,

Pd-103 + Rh-103, *Ag-105, *Ag-111, *Sn-113, *Te-127, *Te-129, *I-132,

*Xe-133, *Cs-137 + *Ba-137, *La-140, Pr-143, Pm-147, *Ho-166, *Lu-177,

*Ta-182, *W-181, *Re-183, Ir-190, *Ir-192, Pt-191, *Pt-193, *Au-196, *Au198, *Au-199, Tl-200, Tl202, Tl-204, *Pb-203, *Hg-197.

Class 4

(slight toxicity)

3H, 7Be, 14C, *18F, *51Cr, 68Ge 71Ge, *87mSr, *99mTc, *111In, *201Tl

(1) This classification is used as part of the evaluation of an application to determine the type of laboratory or workplace standards required. The toxicity ratings are extracted form various published data, but may have been shifted up or down when in the professional judgement of the health physicist local conditions indicate the need.

Appendix D. Workplace Standards for Operations with Unsealed Radioactive Material

All operations with unsealed radioactive materials at Boston College must be conducted in such a manner and in such a workplace, as to minimize the hazard of internal ionizing radiation. The protective measures required by the BC Radiation Safety Committee take into account the nature of the operation, the radionuclides involved, the physical and/or chemical form of the radionuclide, and the quantities that will be used. In the absence of any additional requirements set by the Radiation Safety Committee, this document establishes a set of minimum workplace standards.

I. The following guidelines establish four basic types of workplaces suitable for work involving unsealed radioactive material.

a. Type A - Chemical Laboratory

Most low level uses of radioisotopes can be safely conducted in a normal chemical laboratory, equipped and operated as follows:

1) The ventilation shall provide at least four air changes per hour.

2) Work surfaces for radioactive experiments shall be smooth, impermeable, and covered with absorbent paper.

3) Areas used for work with radioactive material must be clearly marked with radiation warning tape and used only for radioactive work.

4) All radioactive sources shall be stored in cabinets, desiccators, or designated and labeled refrigerators and freezers.

5) Personnel shall wear labcoats, safety glasses and gloves while working with radioactive material.

6) All radioactive material must be secured at the end of the day (laboratory or isotopes must be locked up).

7) Radiation survey meters are required -- as appropriate.

8) Daily contamination monitoring by the user or worker.

9) Contamination of hands, shoes, and clothing shall be checked at the termination of operations.

b. Type B - Chemical Laboratory with Fume Hood

A Type B workplace is used for operations of moderate hazard that require the additional protection of an adequate fume hood.

1) All the requirements for a Type A workplace.

2) Operations with quantities of radioactive material exceeding the limits for a Type A workplace shall be done in a fume hood. The hood must have an average face velocity of 100 lfm (linear feet per minute) with the sash 80% (eighty per cent) open and a maximum face velocity not exceeding 125 lfpm.

3) During the time that Type B quantities are actually in use, users must make regular radiation surveys of their laboratory.

c. Type C - Radioisotope Laboratory

A Type C workplace is required for high hazard operations. A detailed design guide for such a laboratory can be found in the American Standards Association design guide N5 2-1963. The particular details for a given laboratory must be reviewed by the Radiation Safety Committee. In general, they must include the following:

1) All the requirements for a Type B workplace.

2) Restricted access to, and use of the area. i.e., the majority of the work involves use of radioactive material, and no desk space or other "dual" use of the area is permitted.

3) Additional personnel protective garments may be required, such as shoe covers.

4) Sticky paper may be required on the floor at exit from the lab.

d. Type D - High Level Radioisotope Laboratory

A Type D laboratory is required for very high hazard operations. Detailed designs for such a laboratory must be prepared with extensive review by the Boston College Radiation Safety Committee. Such a laboratory may require some or all of the following:

1) Glove boxes.

2) Continuous air monitoring.

3) High efficiency filtration of exhaust air.

4) High level waste collection facilities.

5) Alarm devices to signal excessive levels of airborne radioactivity or external radiation fields.

6) Remote handling facilities.

II. In order to determine the type of workplace required for a particular operation, the relative radiotoxicity of the radioisotope, the physical and chemical form of the material, and the type of manipulations must all be considered. The following analysis is to be considered a guideline for determining minimum workplace requirements for work with a given quantity of material.

If a detailed analysis of a specific experiment and laboratory reveals circumstances not covered in this guide, the Institute Health Physicist may increase or decrease the quantities allowed in a given workplace type.

The following equation is to be used to determine the effective quantity of a radioisotope in a given operation.

Qeff = QAH

where: Qeff = Effective quantity in millicuries; Q = Actual quantity in mCi; A = Action factor; H = Hazard factor.

Qeff is the quantity ultimately used to determine the type of workplace required for a given class of radioisotope. The classes of radioisotopes are determined by the relative radiotoxicity of the radioisotope listed in Appendix C of this manual.

Q is the actual quantity of radioisotope used in the operation.

A is a factor to account for the overall probability that radioactive material may be released to the environment and subsequently inhaled or ingested. This factor involves consideration of the complexity of manipulations and the potential energy released in the operation (i.e. highly exothermic reactions, heating, grinding).

H is a factor to account for additional hazards which exist due to the physical or chemical form of the radioactive material (i.e. nucleic acids, nucleic acid precursors, gases, fine powders, carcinogens, toxins, explosives, aerosols, etc.)

Table I lists action factors and Table II lists hazard factors. When each of the factors applicable to a given experiment has been determined, Qeff can be calculated. Table III is then used to determine the type of workplace required for a particular class of radioisotope.

Table I. Action Factors

Type of Operation	**Action Factor**
Storage	0.01
Very simple, wet operation (Diluting stock solutions, sealed ultra centrifugation solutions, sealed ultra centrifugation washing precipitates, in vitro	0.1

incorporation/incubation, etc.)	
Normal wet chemistry (Precipitation, filtration, bench type centrifugation solvent extraction, chromatography, pipetting or titrating- includes aliquoting stock solutions)	1
Animal injections, complex wet operations (distillation, homogenization, evaporation to dryness). Simple dry operations with non-respirable particles (Fusion reactions, fluorination, transfer of dry precipitates, etc.)	10
Operations which may produce respirable size particles (Dry powders, gaseous except tritium and noble gases, aeration of liquids, use of highly volatile liquids or highly exothermic reactions)	100

Table II. Hazard Factors

Material Hazard Factor

Insoluble or non-metabolizable liquids, solids, or gases	0.1
Metabolizable organics or inorganics	1.0
Nucleic acids and precursors (Not 32P-phosphates.) Skin permeable liquids (DMSO tritiated water, high specific activity (100 mCi/ml) radioactive materials)	10.0
Carcinogens, explosives, extreme toxins	100.0

Table III. Workplace Effective Maximum Radioisotope Quantity as a Function of Toxicity Class

WORKPLACE TYPE

Radionuclide Toxicity Class*	A	B	C	D**
Very High	0.1 µCi	10 µCi	100 µCi	Greater than C quantity
High	1 µCi	100 µCi	1 mCi	"
Moderate	10 µCi	1 mCi	10 mCi	"
Slight	100 µCi	10 mCi	100 mCi	"

* See Appendix C, Table 4.

** Work requiring a Type D workplace may upon exception granted by the RSC; be performed if an adequate Type C workplace is used, written procedures are approved in advance, and the work is done under the supervision of a member of the radiation safety committee.

Appendix E. Radiation Surveys

1. Radiation Levels

Monitor area with a radiation survey meter sufficiently sensitive to detect 0.1 mRem/h. The results of this survey should be recorded on a standard form (Appendix L. Radiation Safety Monthly Inspection Form) which should show:

a. Location, date, and type of equipment used.

b. Identification of person conducting the survey.

c. Sketch of area surveyed, identifying relevant features such as active storage areas, active waste areas, etc.

d. Measured exposure rates, keyed to location on sketch (highlight rates that require corrective action).

e. Corrective action taken in the case of excessive exposure rates, reduced exposure rates after corrective action, and any appropriate comments.

2. Contamination Levels

A series of wipe tests should be taken in all areas where activity is handled in unsealed form. The location of wipe tests should be indicated on the above mentioned survey form and should be chosen for maximum probability of contamination.

Floors, particularly adjacent to doorways, and door and drawer handles should also be wipe tested frequently. Care should be taken that cross contamination does not occur.

An thin end window GM normally may be used for assaying beta emitters at or above C-14 energies; low energy beta emitters will require a gas flow proportional counter or liquid scintillation counting.

A gamma-scintillation counter (example: NaI well counter), should be used for pure gamma emitters. Make sure that the analyzer threshold is set below the lowest gamma energy used in the lab (usually I-125).

Record a background count of 5-10 minutes using the same counting conditions used with the wipes. Always run standards of known activity in order to convert cpm to dpm.

In the case of wipes contaminated with gamma emitters, the radionuclide can be identified from successive counts with different analyzer settings if the settings have been calibrated with known energy standards.

3. Acceptable Limits

a. Radiation Limits (Whole body only):

i. Non-controlled area:

Personnel must not receive more than 2 mRem in any one hour or more than 100 mRem in any one year.

ii. Controlled area:

a. If an area is controlled for purposes of radiation protection, then an investigator's total exposure must be less than 5 Rem/year. On the basis of 40 hours/wk exposure, the maximum exposure rate would have to be less than 2.5 mRem/h. In practice, the radiation levels should be kept as low as reasonably achievable (ALARA) and always below applicable limits.

b. An individual wipe test should routinely cover approximately 100 cm2. Ideally, any contamination more than a few mRem/hr above background should be cleaned up; however, a more usual level for beta or gamma radiation at which cleanup is initiated is 3 times background. At approximately 1 mRem/hr a Contamination Zone should be established until the contamination is removed.

Contamination levels may also be estimated with a survey meter. As a rough rule of thumb, establish a Contamination Zone if readings are greater than 0.1 mRem/hr for Group I and II radionuclides and greater than 1 mRem/hr for Groups III and IV radionuclides when measured with a thin window GM meter. Of course, this particular instrument will not detect low energy beta emitters such as tritium.

c. Patterns of contamination consistently observed at several times background (usually between 0.2 and 1 mRem/hr) in periodic surveys should be noted and reported to the RSO and the principal investigator. The cause for this contamination should be determined and eliminated.

Appendix F. Bioassay Program

Bioassays will be employed to evaluate the exposure levels of individuals working with 125I, 131I, and 3H. The basic procedures to be followed are as outlined in Regulatory Guide 8.20: Applications of Bioassay for 125I and 131I (April 1978) and Regulatory Guide 8.8.32: Criteria for Establishing a Tritium Bioassay Program (July 1988). Compliance with 105CMR120.214 will be monitored for the occupational intake of radioactive material by and assess the committed effective dose equivalent to:

(1) adults likely to receive, in one year, an intake in excess of 10% of the applicable ALI in 105CMR 120.296: Appendix B, Table I, Columns 1 and 2; and

(2) minors and declared pregnant women likely to receive, in one year, a committed effective dose equivalent in excess of 0.05 rem (0.5 millisievert).

The major features of the bioassay programs are as follows:

A. For users of 125I or 131I:

I. Only materials already labelled with 125I or 131I are to be used. Procedures to carry out iodinations with these isotopes are not to be performed.

II. Any individual who will be using unsealed sources of 125I or 131I in excess of 1.0 mCi must notify the Radiation Safety Officer. These individuals must be monitored regularly if using greater than 1.0 mCi repeatedely or must submit to a thyroid scan within 10 days of the last use of greater than 1.0 mCi if using infrequently.

Note: Depending upon the nature of 125I or 131I use, it may be necessary for all individuals frequenting a laboratory where these compounds are used in excess of 1.0 mCi to be assayed as above. (Consult the Radiation Safety Committee for determination of such need.)

III. Individuals who show activity greater than 0.12 µCi 125I or 0.04 µCi 131I will be prohibited from conducting further studies employing the isotope in question until further notified by the Radiation Safety Committee.

IV. a. Individuals who show a positive bioassay (see III above) will be required to have repeated bioassays as determined by the Radiation Safety Committee until acceptable limits are resumed.

Any laboratory whose personnel show a positive bioassay (see III above) will be specifically monitored and its procedures will be reviewed and evaluated by the Radiation Safety Committee to determine if potential hazards exist.

B. For users of 3H:

I. Any individual who will be using unsealed sources of 3H in excess of 10 [50] mCi must notify the University Radiation Safety Officer and will be required to submit a urine sample 1) regularly if using 3H repeatedely or 2) within one week of the last use of greater than 10 [50] mCi if use is infrequent..

Note: The nature of 3H use may require that any individual frequenting the laboratory where greater than 50 mCi is used at any one time similarly submit urine samples. (Consult Radiation Safety Committee for determination of such need.)

III. Individuals who show 3H activity greater than 5 µCi/1 will be prevented from continuing studies employing 3H and will not be allowed to resume until notified by the Radiation Safety Committee. Individuals who show a positive bioassay, and the laboratories whose personnel show a positive bioassay, will be subject to procedures as described in A.IV a. above.

C. For those working with 32P - Ring badge dosimeters should be used to monitor doses to the hands [when individuals work with greater than 1.0 mCi quantities].

APPENDIX G

Procedures & Form for Safely Opening Packages Containing Radioactive Material

1. Visually inspect package for any sign of damage (e.g. wetness, crushed). If damage is noted, stop procedure and notify Radiation Safety Officer.

2. Measure exposure rate at 1 meter from package surface and record. If greater than 10 mRem/hr, stop procedure and notify Radiation Safety Officer.

3. Measure surface exposure rate and record results on form. If greater than 200 mRem/hr, stop procedure and notify Radiation Safety Officer.

4. Put on gloves.

5. Open the outer package (following manufacturer's directions, if supplied) and remove packing slip. Open inner package to verify contents (compare requisition, packing slip, and label on bottle), and check integrity of final source container (inspecting for breakage of seals or vials, loss of liquid, discoloration of packaging material). Check also that shipment does not exceed possession limits.

6. Wipe external surface of outer container and final source container with moistened cotton swab or filter paper held with forceps; assay and record on form below.

7. Monitor the packing material and packages for contamination before discarding.

a. If contaminated, treat as radioactive waste.

b. If not contaminated, obliterate radiation labels before discarding in regular trash.

In all of the above procedures, take wipe tests with a paper towel, check wipes with a thin-end-window GM survey meter, and take precaution against the spread of contamination as necessary.

8. Fill out the following Radioisotope Shipment Receipt Report and send copy to the Office of Environmental Health and Safety.

RADIOISOTOPE SHIPMENT RECEIPT REPORT

1. PO# ______________________________ Survey Date: ___/___/___ Time: _______

Supplier: NEN: _____________ Surveyer______________________________

Amersham: _________ (PRINT)

Other: _____________

2. CONDITION OF PACKAGE:

Good ______ Crushed ______ Punctured ______

Wet ______ Other (specify) ______________________

3. CONTENTS:

Isotope: _______________________

Chemical Form: ________________

Quantity: _________________(mCi)

Do vial contents and package slip agree? Yes ___ No ___

If no, specify nature of difference:

____

4. TEST RESULTS:

a) Test Type (x): Wipe ____ Survey Meter _____

Amounts: a) Backgrounds: Wipe______ CPM GM __________ CPM

b) Outer Container: Wipe ______CPM Surface: _______ CPM

1 m: ______ CPM

c) Final Source Container: Wipe ______CPM Surface: _______ CPM

1m: _______ CPM

5. PACKAGE DELIVERED TO: Dr. ______________________ Dept. of __________________

6. IF NRC/CARRIER NOTIFICATION IS REQUIRED, GIVE

Date: ___/___/___ Time: __________ Person Notified:______________________

7. SIGNATURE OF Radiation Safety Technician/RSO or ARSO:

____

Appendix H. In Vivo Labelling Studies Procedures

1. In vivo labeling experiments are to be conducted only by individuals whose protocols have been approved by both the University Committee on the Care and Use of Animals (UACC), to ensure adherence to guidelines for the humane treatment of animals during the course of the experiments, and the University Radiation Safety Committee (RSC) to ensure proper isotope handling and monitoring.

2. All such studies are to be conducted in facilities which are designed for this purpose and approved by the RSC.

3. All cages and other materials for use in these in vivo labeling studies will be kept in the designated room and its environs and shall be used exclusively for such studies, i.e. these cages and other materials will not be used for routine animal housing, maintenance, or experimentation.

4. At the conclusion of the in vivo labeling experiment (irrespective of duration) the following procedures must be followed:

a. All bedding materials must be suitably disposed of as radioactive solid waste;

b. All cages and areas used in the study must be thoroughly cleaned by the investigator;

c. All such cages and areas must be monitored carefully to ascertain that they are free of any detectable radioactive contaminants;

d. All carcasses must be disposed of in a garbage grinder such that the concentrations of the pertinent radionuclide are within those specified for sink disposal.

5. The direct responsibility for overseeing and manipulating the organisms carrying radioisotopes (and the cages and other materials) during the in vivo experiments rests with the investigator personally-- subject to the advisements and directives of the Director of Animal Facilities and the UACC with regards to animal well-being. No individual who has not been specifically approved by the RSC for direct use of radioisotopes will be involved with the animals or materials used in any in vivo labeling experiment.

Radioactive Nucleic Acids and Derivatives

Experiments involving the use of radioactive nucleic acid and radioactive nucleic acid derivatives present a special hazard in that some of these compounds have been incorporated. The following procedures have been adopted by the Radiation Safety Committee for the use by all workers involved with such material.

1. Special care should be used during all experiments which involve the use of radioactive nucleic acids, radioactive nucleic acid derivatives, or substances in which these compounds have been incorporated.

2. When the quantity of a radioactive isotope used in any one experiment is less than 200 µCi, the following precautions suffice:

a. The experiment should be done only in a designated area within the laboratory. This area should be physically separated from other work areas if at all possible. The bench top should always be covered with absorbent paper.

b. Rubber or plastic gloves and lab coats should be worn at all times during the handling of the radioactive materials.

3. When the quantity of a radioactive isotope used in any one experiment exceeds 200 µCi, experimental manipulations must be carried out in a fume hood. Radiation Safety should be consulted concerning the adequacy of fume hoods used for this purpose (Appendix D).

Application to Use Radioactive Materials in Animals

Principal Investigator Dept. Ext.:

Personnel Assigned to the Project Ext.:

Brief Description of the Project

Identity of Radioactive Material:

Source: Storage Location:

Administration of Material per Animal: Preparation: Dose:

Frequency: Total Dose: Method of Administration:

Animals Proposed for Project:

Species Strain Quantity Proposed Date:

Amount of Biohazardous Material, Radionuclide or Toxic Metabolite Secreted/Excreted after Dosing: a) Urine c) Expired Air

b) Feces d) Time Frame

e) Skin application and length of activity after application

Protocol Number

1. What is the specific method of chemical neutralization and/or decontamination for this

material?

Reference

2. If there is no known method of decontamination, will double washing of equipment and

incineration of waste materials be sufficient safety precautions to meet the needs of this

project? Yes No

3. What protective garments are necessary for personnel assigned to this project to ensure

maximum safety? (It is the responsibility of the investigator to provide these.)

All projects involving the use of any biohazardous materials or radioactive substances must be performed in accordance with UACC safety protocols for these substances.

Signature of the Principle Investigator Date:

FOR UACC USE ONLY

Date Received: Animal Care Personnel

Space Assigned: Associated with Project

Approval:

Animal Care Supervisor Radiation Safety Officer

Appendix I. Calibration of Survey Meters Procedures & Frequency

A list of university meters and calibration due dates is maintained at the Radiation Safety Office.

Survey meters and associated probes will be collected when they are due for calibration by the RST and will be sent to a an outside vendor to be calibrated according to NRC guidelines. Meters will be collected in two batches so that half of all meters on campus will be available at all times. Meters are calibrated for both exposure monitoring and contamination surveys.

New meters purchased by laboratories will usually arrive on campus with a calibration due date sticker attached. When these meters reach their due dates, it is the responsibility of the researchers to notify the RST to have the meter sent out for calibration. At this time it will be added to the Radiation Safety Office calibration list.

If you wish to receive a copy of the calibration report for your meter and probe please be sure that your laboratory PI's name is on the meter, otherwise all reports will be reviewed by the RSO and filed in the Radiation Safety Office.

Appendix J. Notice to Workers in Radioisotope Use Areas

The following notice and the form NRC-3 will be posted in all radioisotope use areas.

Radiation Safety Officer:

Laboratory Supervisor:______________________________

Parts 10 CFR 19 and 10 CFR 20, "Rules and Regulations", U.S. Nuclear Regulatory Commission (NRC) and copies of the Boston College License and appendices thereto, together with all relevant correspondence from the NRC are kept on file in the Radiation Safety Office at St. Clements Hall Room 120 and are available to all personnel on request. Also available at the Radiation Safety Office are the Commonwealth of Massachusetts regulations 105.CMR120, conditions of associated documents, associated procedures which support the license, and any notices of violations involving radiological working condititons, proposed imoposition of civil penalty, or order pursuant to 105CMR120.001, and any response from the lecensee or registrant.

EMERGENCY PROCEDURES:

A. MINOR SPILLS:

1. NOTIFY: Notify persons in the area that a spill has occurred.

2. PREVENT THE SPREAD: Cover the spill with absorbent paper.

3. CLEAN UP: Use disposable gloves and remote handling tongs. Carefully fold the absorbent paper and pad. Insert into a plastic bag and dispose of in the radioactive waste container. Also insert into the plastic bag all other contaminated materials such as disposable gloves.

4. SURVEY: With a low-range, thin-window G-M survey meter, check the area around the spill, hands, shoes and clothing for contamination. For 3H take appropriate wipe samples.

5. REPORT: Report incident to the Radiation Safety Officer.

B. MAJOR SPILLS:

1. CLEAR THE AREA: Notify all persons not involved in the spill to vacate the room.

2. PREVENT THE SPREAD: Cover the spill with absorbent pads, but do not attempt to clean it up. Confine the movement of all personnel potentially contaminated to prevent the spread.

3. SHIELD THE SOURCE: If possible, the spill should be shielded, but only if it can be done without further contamination or without significantly increasing your radiation exposure.

4. CLOSE THE ROOM: Leave the room and lock the door(s) to prevent entry.

5. CALL FOR HELP: Notify the Radiation Safety Officer immediately. Evenings and weekends call Campus Police at ext. 4444. and tell them to the RSO.

6. PERSONNEL CONTAMINATION: Contaminated clothing should be removed and stored for further evaluation by the Radiation Safety Officer. If the spill is on the skin, flush thoroughly and then wash with mild soap and lukewarm water.

C. ACCIDENT REPORTS: All accidents involving possible individual or area contamination must be reported immediately to the Radiation Safety Officer or by the departmental representative to the Radiation Safety committee, who in turn will inform the Radiation Safety Officer.

D. LOG BOOK: Maintain binder of all inspection reports, shipment receipt reports, and up-to-date isotope log sheets.

Appendix K. Suggested RSC Meeting Agenda Items

The following items should be covered at least annually at RSC meetings:

1. Minutes of previous meeting.

2. Review of new user applications.

3. Report of the RSO on periodic review of dosimetry reports to identify any reported exposures which require additional investigation or response or that exceed the limits set forth in Section II A & B of the BC-RSM.

4. The second semester (February) meeting should: a) include the annual review of the

radiation safety and ALARA programs (BC-RSM Section I.B.2.c), and b) verify that the Directors of Security and Housekeeping have received their annual reminder of current ules and procedures (I.B.2.h).

5. Review results of monthly area surveys. Discuss results of the semi-annual inspection of radioisotope use sites (BC-RSM Section I.B.2.f).

6. Discuss status of the storage facility for radioactive wastes.

7. Verify that holdings of radioisotopes are within licensed limits. Review limits for individual users.

8. Check that bi-annual wipe tests of sealed sources has been done.

9. Check that the annual calibration of monitoring devices has been accomplished.

Appendix L. Radiation Safety Program - Monthly Inspection Form

Principle Investigator:______________________________

• Higgins • Merkert • Devlin • Other:_________

Laboratory Room Number(s): ___________________ Date: ____/_____/_____

1. Indicate Isotope(s) used in laboratory: 35S 32P 14C 3H Other:_____

2. Isotope inventories are within allowed limit: Yes No N/A

3. Warning signs are properly posted. Yes No N/A

4. Are emergency contact #’s posted by telephone? Yes No N/A

5. There is no indication of food in the lab. Yes No N/A

6. Are rudimentary safety procedures are posted. Yes No N/A

7. Is waste stored in designated waste receptacles? Yes No N/A

8. Are postings (DPH -Notice to employees) present? Yes No N/A

9. Are Self-monitoring and Sink Logs filled out? Yes No N/A

10. Are Inventory and Disposal Logs up to date? Yes No N/A

11. Are stock solutions secured? Yes No N/A

12. Does lab need to be re -inspected? Yes No N/A

Monitoring Results:

Reference Point GM Wipe Test

(RP No.) (mR/hr) (dpm/100cm ^{2})

Bkgrnd N/A

_______ ______ ______

_______ ______ ______

_______ ______ ______

_______ ______ _____

_______ ______ ______

_______ ______ ______

_______ ______ ______

_______ ______ ______

______ _____ _____

Reviewed by: Rob MacCormick/RSO

Initials:__________ Date:____________

Appendix M. Label for Decay of Isotope in Storage

1. Write the label designation directly on the plastic bag containing the wastes with the initials of the principal investigator, date, and bag number, i.e. MJC-7/2/92-#3.

2. Complete required information on this form for any radioactive waste, which is being held for decay in storage and make 2 copies.

3. Fix the label to the bag. Give bag to the RST. Retain a copy for your records.

4. Before disposal (after 10 half-lives), the RST will survey the wastes in a low background area with a low-level survey meter with all shielding removed. Decayed waste cannot be disposed of as normal trash unless the radiation level is at background.

5. The date of disposal will be recorded on the copy of the label kept in the BC Radiation Waste Storage Facility.

Radioactive Waste Held for Decay in Storage

Bag Designation: (PI's Initials, Date, Bag Number): ______ - ____/____/_____ - #____

Isotope Amount t1/2 Date Est. Date for

(circle) (μCi) (days) Stored Normal Disposal

32P	_____	14.3	___/___/___	___/___/___
35S	_____	88	___/___/___	___/___/___
125I	_____	60	___/___/___	___/___/___
_____	______	_____	___/___/___	___/___/___

Survey Meter Reading at time of Disposal: ______________________________

Removable Levels at time of Disposal: ______________________________

Date of Disposal : ______________________________

Name of Disposer: ______________________________

Appendix N.

BOSTON COLLEGE
OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY
RADIATION SAFETY OFFICE

WORKER REGISTRATION FORM

SECTION I Date

1. Name

(Print) Last First M.I.

2. Social Security Number

Birth Date

3. Department Supervisor

4. Faculty Staff Student Other

Title

5. Office No. Ext.
Lab No. Ext.

6. Project Supervisor

7. Brief description of present work with radiation:

8. Principal radiation material to be used in your present work:

RADIONUCLIDE(s)

TOTAL ACTIVITY

ORDERED

(MCi) CHEMICAL OR

PHYSICAL FORM

ORDERED MAXIMUM AMOUNT USED PER EXPERIMENT

9. Radiation producing equipment to be used in your present work:

Type ______________________ Maximum Energy____________________________

SECTION II PREVIOUS EXPERIENCE WITH RADIATION

1. Previous Experience with radioactive material:

RADIONUCLIDE(S) GREATEST

ACTIVITY USED

DATES

EMPLOYER(S) NAME AND ADDRESS

FROM
TO

2. Previous experience with radiation producing equipment:

TYPE(S) OF EMPLOYER(S)

NAME

DATES

EQUIPMENT AND ADDRESS

FROM

TO

3. Have you had an internal radiation exposure in amounts known (or suspected) to be above the

permissible limits?
YES NO UNKNOWN

for occupational exposure?
YES NO UNKNOWN

4. Has your occupational exposure to external radiation totaled more than 500 mrem (or 500 mrad) in any one year? YES NO UNKNOWN

The Boston College Radiation Safety Manual is available to me through my Principal Investigator and on line with the EH&S computer. I have received and read Regulatory Guide 8.13, Instruction Concerning Prenatal Radiation Exposure and Regulatory Guide 8.29, Instruction Concerning Risk from Occupation Radiation Exposure. I have attended the radioactive materials safety course and was afforded the opportunity to ask questions addressing any concerns I have relating to potential occupation radiation exposure.

If necessary, I give the Radiation Safety Officer permission to request my radiation exposure history from previous employers.

I agree to comply with 1) all applicable Boston College rules and regulations governing the safe use of radioactive materials and 2) the conditions of approval listed on my project authorization, approved by the Boston College Radiation Safety Committee

____

Signature

____

Date

SECTION III TO BE COMPLETED BY THE RADIATION SAFETY OFFICE

Interviewed by:

Date:

Type of Interview:
Radioisotope:
X-ray:
Accelerator:

Instruction Material Supplied:
Manual:
Information Sheets:

Regulatory Guides 8.13 and 8.29:

Other:

Authorization No.:

Supervisor:

Date Terminated:

Date Reactivated:

Dosimetry:
Yes:
No:
Body:
Wrist:
Finger:

Spare Badge #:

Reference #:

Issue Date:

Termination Date:

Other:

Bioassay:
Yes:
No:

Urinalysis:
Radionuclides:

In vivo Measurements:
Whole Body:
Thyroid:

RADIATION SAFETY INSTRUCTION QUIZ

Use this form to record your answers. DO NOT MARK THE QUIZ!

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

12.

13.

14.

15.

16.

17.

18.

19.

20.

BOSTON COLLEGE
Radiation Safety Office
St. Clements Hall

Appendix O. Principal Investigator Application Form

New User/User Update (circle one) Appl. Date ____/____/____

Name ________________________________Dept. ______ Apprvd. Date ____/____/____

Office ________Building __________ Extension ________Exp. Date ____/____/____

Isotopes to be used in:

Room ________ Building __________ Lab Extension ___________

Room ________ Building __________ Lab Extension ___________

Isotopes Used: Physical/ Amount Used Total Requested Principal Chemical in Typical Posession

Isotope Emission t1/2 Form Experiment Limit

(µCi) (µCi)

___ 3H ß- (0.02 MeV) 12.26 y _____________ _____ _____

___ 14C ß- (0.16 MeV) 5,730 y _____________ _____ _____

___ 32P ß- (1.7 MeV) 14.3 d _____________ _____ _____

___ 35S ß- (0.16 MeV) 88 d _____________ _____ _____

___ Other _________ _____ _____________ _____ _____

Purpose and Nature of Use (Also cite specific operations that may affect contamination and/or exposure (e.g. grinding, evaporations, volatile compounds, etc. Attach additional sheets.):

Training:

Attach form: "Record of Personnel Training & Isotope Use" Appendix N.

PI APPLICATION FORM

Monitoring Devices:

Available in Laboratory Available for Use

from Other Site (give location)_________________

___ Whole Body Dosimeter

___ Ring Badges

___ Geiger Counter ____ Geiger Counter ________________________

___ Scintillation Counter ____ Scintillation Counter ____________________

___ Other_______________

Storage and Disposal Methods:

The radioisotope material will be stored and disposed of in the following manner (attach sheet if necessary):

Safety Procedures:

Describe safety procedures to be implemented while carrying out work with this (these) isotopes. Be specific for each isotope.

PI AUTHORIZATION

As principal investigator for research using the specified radioisotopes, I certify that I am familiar with the regulations for radioisotope use as specified in the BC Radiation Safety Manual and that a copy of this is available in my laboratory; also, that workers under my supervision have been provided with written guidelines for handling the specified isotopes. (Application will not be reviewed unless copy of analytical procedures is attached.)

____ Date ___/___/___

Principal Investigator

____ Date ___/___/___

RSO/ARSO Approval

Note: Permission to use radionuclides automatically expires after 5 years.

Appendix P. Request for Radiation Exposure Records

BOSTON COLLEGE
140 Commonwealth Avenue
CHESTNUT HILL, MA 02167

Radiation Safety
Environmental Health & Safety Office
St. Clements Hall
(617) 552-0363

Date:

To:

Re: Occupational Radiation Exposure Records

In accordance with the recommendations of the NCRP and in compliance with the revised Title 10 CFR, Part 20, and 105CMR120.265, this office compiles occupational radiation exposure histories for all personnel who have worked with sources of ionizing radiation.

Please forward the pertinent data for:

Name:

Social Security No.:

Period of Exposure:

Department:

This information should come from documented records in your files and should indicate the method of monitoring (film badge, bioassay, or other) and the total dose for the exposure period in mRem.

Authorization for the release of my radiation exposure history to Boston College is hereby given:

Signature:

Date:

BOSTON COLLEGE
Radiation Safety Office

St. Clements Hall