California Polytechnic State University
San Luis Obispo

Radiation Safety Manual

Radiation Safety Committee
November, 1999

1. DEFINITIONS

Activity

Activity is the rate of disintegration (transformation) or decay of radioactive material. The units of activity are the curie (Ci) and the becquerel (Bq).

Airborne Radioactive Area

Any room, enclosure, or area in which airborne radioactive material, composed wholly or partly of licensed material, exist in concentrations:

- In excess of the derived air concentrations (DACs) specified in Appendix B, to §§ 20.1001 – 20.2401 of Title 10, Code of federal Regulations, Part 20, Energy, (hereafter known as 10CFR20), and incorporated by reference in the California Code of Regulations, Title 17, Public Health, Division 1, Department of Health Services, Chapter 5, Sanitation, Subchapter 4, radiation, Group 3, Standards for Protection Against Radiation, Article 1, General, Section 30253 (a)(1), (hereafter known as CCR),
- To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.[1]

Airborne Radioactive Material

Any radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

ALARA

ALARA (acronym for ``as low as is reasonably achievable'') means making every reasonable effort to maintain exposures to radiation as far below the dose limits in this part as is practical consistent with the purpose for which the licensed 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 licensed materials in the public interest.

Annual Limit on Intake

Annual limit on intake (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems (0.05 Sv) or a

committed dose equivalent of 50 rems (0.5 Sv) to any individual organ or tissue.

Application for Sub-License Use of Radionuclides

An application which precedes the issuance of a Radiation Sub-license. Separate applications are required for non-human research use, non-human classroom use, and radiation producing machines.

Background Radiation

Background radiation means radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. ``Background radiation'' does not include radiation from source, byproduct, or special nuclear materials regulated by the State Department of Health Services or by the Nuclear Regulatory Commission.

Becquerel (Bq)

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

Bioassay

Bioassay (radio-bioassay) means the determination of kinds, quantities or concentrations, and, in some cases, the locations of radioactive material in the human body, whether by direct measurement (in vivo counting) or by analysis and evaluation of materials excreted or removed from the human body.

Brachytherapy

A method of radiation therapy in which sealed sources are utilized to deliver a radiation dose at a distance of up to a few centimeters, by surface, intracavity, or interstitial application[2].

Byproduct Material

Byproduct material means any radioactive material, except special nuclear material, yielded in or made radioactive by exposure to radiation incident to the process of producing or utilizing special nuclear material.

CCR Title 17

Refers to the California Code of Regulations, Title 17, Public Heath, and all applicable Divisions, Chapters, Subchapters, Articles, and Sections as they relate to radiation, radioactive materials, radiation producing machines, radiation protection standards, radioactive material controls, licensing, and related topics.

Calendar Quarter

A period of time equal to one-fourth of the year observed by the licensee (approximately 13 consecutive weeks), providing that the beginning of the first quarter in a year coincides with the starting date of the year and that no day is omitted or duplicated in consecutive quarters.

California Radiation Control Law

Also known as “Act” within CCR Title 17, this refers to the Radiation Control Law, Health and Safety Code, Part 9, chapter 8, sections 114960 et seq.

Class

Class (or lung class or inhalation class) means a classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

Committed Dose Equivalent (CDE)

Committed dose equivalent (H_T,50) means the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE)

Committed effective dose equivalent (H_E,50) is 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 ($H_E,50 = \Sigma w_T H_T,50$).

Controlled Area

Controlled area means an area, outside of a restricted area but inside the license defined use locations, access to which can be limited by the licensee for any reason.

Curie
The basic unit of activity is the curie (Ci). A sample has an activity of one curie if it is decaying at a rate of 3.7 E10 disintegrations per second (dps). Sub-units of the curie are:

milli-curie (mCi)	=	3.7 E7 dps
micro-curie (uCi)	=	3.7 E4 dps
picocurie (phi)	=	3.7 E-2 dps

The international unit for activity is the becquerel (Bq). The becquerel (Bq) is equal to one (disintegration or transformation) per second with units of $second^{-1}$.

Declared Pregnant Woman

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

Deep Dose Equivalent

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

Department

Refers to the California Polytechnic State University Risk Management Program / Environmental Health and Safety Office .

Depleted Uranium

Uranium having a percentage of Uranium-235 smaller than the 0.7% found in natural Uranium.

Derived air concentration

Derived air concentration (DAC) means the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhalation rate 1.2 cubic meters of air per hour), results in an intake of one ALI. DAC values are given in *Table 1, Column 3, of appendix B to 10CFR20, sections 20.1001-20.2401.*

Derived air concentration-hour (DAC-hour)

Derived air concentration-hour (DAC-hour) is the product of the concentration of radioactive material in air (expressed as a fraction or multiple of the derived air concentration for each radionuclide) and the time of exposure to that radionuclide, in hours. A licensee may take 2,000 DAC-hours to represent one ALI, equivalent to a committed effective dose equivalent of 5 rems (0.05 Sv).

Dose

Dose or radiation dose is a generic term that means absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or total effective dose equivalent, as defined elsewhere in this document.

Dose equivalent (H_T)

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

E

This is used in this manual to indicate an exponent 10 raised to a power, for example 1.0 E2 = 1.0 x 10 squared.

Effective Dose Equivalent

Effective dose equivalent (H_E) is the sum of the products of the dose equivalent to the organ or tissue (H<INF>T) and the weighting factors (w<INF>T) applicable to each of the body organs or tissues that are irradiated ($H_E = \Sigma w_T H_T$).

Exposure

Exposure means being exposed to ionizing radiation or to radioactive material.

Extremity

Extremity means hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

Eye Dose Equivalent

Eye dose equivalent applies to the external exposure of the lens of the eye and is taken as the dose equivalent at a tissue depth of 0.3 centimeter (300 mg/cm^2).

Fire Hazard Classification (FHC)

Priority System used for emergency pre-plans to identify hazards encountered or associated with the use of radioactive materials in laboratories and rooms.

Gray

A unit, in the International System of Units (SI), of absorbed dose which is equal to 1 Joule per kilogram. 1 gray = 100 Rads

High Radiation Area

High radiation area means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.1 rem (1 mSv or 100 milli-rem) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Hazard Rating (HR)

Used for evaluating, approval, and renewal of Sub-Licenses by the RSO and Radiation Safety Committee.

High Radiation Area

Any area accessible to individuals, in which radiation exists at such levels that an individual could receive in any one hour, a dose to the whole body in excess of 100 milli-rem (1.0 milli-sievert).

Human Use

The external or internal administration of radiation or radioactive material to human beings.

Individual Monitoring

Individual monitoring means--
(1) The assessment of dose equivalent by the use of devices designed to be worn by an individual;
(2) The assessment of committed effective dose equivalent by bioassay (see Bioassay) or by determination of the time-weighted air concentrations to which an individual has been exposed, i.e., DAC-hours; or
(3) The assessment of dose equivalent by the use of survey data.

Individual Monitoring Devices

Individual Monitoring Devices (individual monitoring equipment) means devices designed to be worn by a single individual for the assessment of dose equivalent such as film badges, thermoluminescent dosimeters (TLDs), pocket ionization chambers, and personal (``lapel'') air sampling devices.

Internal Dose

Internal dose means that portion of the dose equivalent received from radioactive material taken into the body.

Installation
The location where one or more reportable sources of radiation are possessed.

Ionizing Radiation

Any electromagnetic or particulate radiation capable of producing ions directly or indirectly in its passage through matter. In general, it will refer to gamma rays and x-rays, alpha and beta particles, neutrons, protons, high speed electrons, and other nuclear particles; not sound or radio waves, or visible, infrared, or ultra-violet light.

License

Except where otherwise specified, means a license issued pursuant to Group 2, Licensing of Radioactive Material in CCR Title 17, and all applicable sections.

Licensed Material

Licensed material means any radioactive material including source material, special nuclear material, or byproduct material received, possessed, used, transferred or disposed of under a general or specific license issued by the Nuclear Regulatory Commission or an Agreement State. With respect to dose limits and reporting requirements, the term “Licensed Material” is to be construed broadly in context to include any source of ionizing radiation subject to the requirements of Title 17, California Code of Regulations, Division 1, Chapter 5, subchapter 4.

MPBB

Formerly used to denote the Maximum Permissible Body Burden. This term is not currently used. Internal exposures are now measured against the Annual limit on intake (**ALI**).

MPC

Formerly used as an acronym to denote Maximum Permissible Concentration. This term is no longer used. Concentrations of radioactive materials in air are now measured against the derived air concentration (**DAC**).

Nonstochastic Effect

Nonstochastic effect means health effects, the severity of which varies with the dose and for which a threshold is believed to exist. Radiation-induced cataract formation is an example of a nonstochastic effect (also called a deterministic effect).

NRC
Nuclear Regulatory Commission which replaces regulatory functions of the Atomic Energy Commission.

Occupational Dose

Occupational dose means the dose received by an individual in the course of employment, education, training, or other activities in which the individual's assigned duties involve exposure to radiation and/or radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include doses received from background radiation, from any medical administration the individual has received, from voluntary participation in medical research programs, or as a member of the public.

Personnel Dosimetry

Individual monitoring devices which measure the cumulative dose of radiation to an individual. Includes film badges, TLD rings, pocket chambers, and pocket dosimeters.

Personnel under Supervision

Any individual engaged in activities subject to regulations and controlled by a Sub-Licensee, but does not include the Sub-Licensee.

Possession

To receive, possess, use, transfer, or dispose of radioactive material pursuant to regulation.

Radiation

Radiation (ionizing radiation) means alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, protons, and other nuclear particles but not sound or radio waves, or visible, infrared, or ultraviolet light.

Radiation Absorbed Dose (rad)

A measurement of the dose of any radiation in terms of the energy absorbed per unit mass. One rad is the absorbed dose corresponding to the absorption of 100 ergs per gram. The international unit of absorbed dose is the gray (Gy). 100 rad equals 1 gray.

Radiation Area

Radiation area means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation
penetrates.

Radiation Producing Machine

Any device capable of producing radiation when the associated control devices are operated, but excluding devices which produce radiation only by the use of radioactive materials.

Radiation Safety Committee

The Cal Poly Radiation Safety Officer and members of the Cal Poly faculty who are appointed by the President to fulfill the requirements of CCR Title 17 30195(1).

Radiation Safety Officer (RSO)

Member of the Radiation Safety Committee, and who is qualified by reason of training and experience to oversee the radiation safety aspects of radioactive material use in the institution. Appointed by the President to fulfill requirements of 17CCR30195.

Radiation Contamination

Deposition of radioactive material in any place where it is not desired.

Radioactive Materials

Any material, solid, liquid, or gas which emits ionizing radiation spontaneously.

Reportable Sources of Radiation

Refers either to: Radiation machines, when installed in such a manner as to be capable of producing radiation, OR radioactive material contained in devices designed and manufactured for the purpose of detecting, measuring, gauging, controlling thickness, density, level, interface location, radiation, leakage or qualitative or quantitative chemical composition, for producing light or an ionized atmosphere, possessed pursuant to a general license under provisions of Section 30192.1 of Group 2 of CCR Title 17.

Roentgen

The quality of x or gamma radiation that results in 1 electrostatic unit (esu) of ionization per 1 cc STP of dry air at the point of measurement. One esu represents 2 E9 ion pairs, or 2.58 E-4 coulombs/kg air. The amount of radiation imparts an amount of energy equivalent to 5.4 E7 MeV per gram or air, or 0.87 rad to air. A roentgen of x-radiation in the energy range of 0.1-3 MeV also produces 0.9 rad in tissue. Thus, for most purposes, values of exposure in roentgens can be considered essentially equal to absorbed doses in rads to tissue irradiated at the same point or to dose equivalents in rem.

Roentgen Equivalent Man (rem)

The unit used to express human dose equivalence as a result of exposure to ionizing radiation. The relation of the rem to other dose units depends upon the biological effect of the radiation under consideration. For the purposes of this manual[3], any of the following is considered to be equivalent to a dose of one rem:

1. A dose of one rad due to x, gamma, or beta radiation.
2. A dose of 0.1 rad due to neutrons or high energy protons.
3. A dose of 0.05 rad due to particles heavier than protons with energy to reach the lens of the eye.
4. An exposure of 25 E6 neutrons per square centimeter, or in accordance with the f table 1.1 if the energy of the neutrons is known:

Table 1.1
Neutron Energy and Fluence to Yield 1 rem

Neutron Energy (MeV)	Number of Neutrons Per Square Centimeter Equivalent to a DOSE of 1 rem
Thermal	980 E6
O.0001	840 E6
0.001	980 E6
0.01	1010 E6
0.1	170 E6
0.5	39 E6
1.0	27 E6
2.5	29 E6
5.0	23 E6
7.0	24 E6
10.0	24 E6
40.0	14 E6

The international unit of dose equivalence is the sievert (Sv). 100 rem equals 1 sievert.

Sealed Source

Any radioactive material that is permanently encapsulated in such a manner that the radioactive material will not be released under the most severe conditions likely to be encountered by the source.

Sievert (Sv)

A unit, in the International System of Units (SI), of dose equivalent which is equal to 1 joule per kilogram. 1 sievert = 100 Rem.

Shallow-Dose Equivalent

Shallow-dose equivalent (H_S), which applies to the external exposure of the skin or an extremity, is taken as the dose equivalent at a tissue depth of 0.007 centimeter (7 mg/cm^2) averaged over an area of 1 square centimeter.

Source Material

Source material means--
(1) Uranium or thorium or any combination of uranium and thorium in any physical or chemical form; or
(2) Ores that contain, by weight, one-twentieth of 1 percent (0.05 percent), or more, of uranium, thorium, or any combination of uranium and thorium. Source material does not include special nuclear material.

Source of Radiation

A discrete or separate quantity of radioactive material or a single radiation machine.

Special Nuclear Materials

Special nuclear material means--
(1) Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Department declares by rule to be special nuclear material after the United States Nuclear Regulatory Commission, or any successor thereto, has determined the material to be such, but does not include source material; or
(2) Any material artificially enriched by any of the foregoing but does not include source material.

Specific License

A license or the equivalent document issued to a named person by the Department of Health Services or by the Nuclear Regulatory Commission or by any other Agreement State.

Stochastic effects

Stochastic effects means health effects that occur randomly and for which the probability of the effect occurring, rather than its severity, is assumed to be a linear

function of dose without threshold. Hereditary effects and cancer incidence are examples of stochastic effects.

Sub-License

An authorization issued by the Cal Poly Radiation Safety Committee and Radiation Safety Officer to use specific radioisotopes or ionizing radiation producing machines.

Sub-Licensee

Any person who is licensed to possess radioactive material or has registered as possessing a reportable source of radiation pursuant to CCR Title 17, or otherwise possesses a source of radiation which is subject to such license or registration..

Survey

Survey means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present. An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of sources of radiation.

Total Effective Dose Equivalent (TEDE)

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

Uncontrolled Area

Unrestricted area means an area, access to which is neither limited nor controlled by the licensee.

University Radioactive Material License

A license issued by the Nuclear Regulatory Commission or State of California Department of Health Services to Cal Poly. It is a Type B broad scope non-medical academic license for the use of radioisotopes in research, instruction, and authorized application throughout the Cal Poly campus.

Weighting Factor

Weighting factor w_T, for an organ or tissue (T) is the proportion of the risk of stochastic effects resulting from irradiation of that organ or tissue to the total risk of stochastic effects when the whole body is irradiated uniformly. For calculating the effective dose

equivalent, the values of w_T are:

Table 1.2
Organ Dose Weighting Factors

Organ or Tissue	w_T
Gonads	0.25
Breast	0.15
Red bone marrow	0.12
Lung	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder	0.3[1]
Whole Body	1.0[2]

10CFR20

Refers to the Code of Federal Regulations, Title 10, Energy, Chapter 1, Part 20, Standards for Protection Against Radiation. Other parts of the federal regulations exist and may be applicable. Other parts of Title 10 are identified as 10CFRXX where the XX is replaced by the part number (e.g. part 30 = 10CFR30).

[1] 0.30 results from 0.06 for each of 5 ``remainder'' organs (excluding the skin and the lens of the eye) that receive the highest doses

[2] For the purpose of weighting the external whole body dose (for adding it to the internal dose), a single weighting factor, w_T=1.0, has been specified. The use of other weighting factors for external exposure will be approved on a case-by-case basis until such time as specific guidance is issued

2. ADMINISTRATIVE PROCEDURES AND RESPONSIBILITIES

The purpose of the Radiation Safety Program is to assure the safe use of ionizing radiation through training, consultation, and surveillance consistent with government regulations.

The California Polytechnic State University, San Luis Obispo, (hereinafter referred to as “CPSU”) Radiation Safety Manual sets the standards of operations for the Radiation Safety Program. This guide is prepared for sub-licensees as an aid in complying with the University’s License for use of radioactive materials.

2.1 (RESERVED)

2.2 Radiation Safety Committee

A. Functions

The Radiation Safety Committee shall advise the President on all policy matters relating to radiation safety; formulate campus radiation safety policies in compliance with regulations of the State of California Department of Health Services, monitor the performance of the Radiation Safety Officer as that performance relates to implementation of policy and adherence to procedures, particularly in the following areas:

(1) evaluating all proposals for, and maintaining surveillance over, all uses of radiation producing machines and radioactive materials, and

(2) assuring that all such uses conform to provisions of the Campus Radiation Safety Manual, and county, state and federal regulations as directed by the President.

The Radiation Safety Committee may recommend changes in the duties of the Radiation Safety Officer and will participate in the selection of the Radiation Safety Officer when a vacancy occurs.

Recommendations for action from the committee should be addressed to the Radiation Safety Officer and/or appropriate dean division head for action or for forwarding to the President for review and action. The committee will provide an annual report to the President summarizing committee activities and actions.

B. Membership

The committee membership is appointed by and reports to the President. The chairperson will be selected by the Committee and must meet the qualifications of the Department of Public Health as required for licensure by that agency.

The Radiation Safety Committee will consist of:

One faculty member, nominated by the appropriate Dean, from each College within the University which uses radiation sources (currently Agriculture, Engineering, Science and Mathematics)

One science technician, nominated by the Dean of the School of Science and Mathematics.

One Health Center physician, nominated by the Dean of Students, to service as medical consultant,

Radiation Safety Officer (Executive Secretary), permanent member.

The term of office will be two (2) years. Terms of office will be staggered so as to assure committee continuity.

C. Meetings

Meeting will be held once each quarter and on the call of the chairperson. Meetings may be cancelled if a majority of a quorum of the Radiation Safety Committee agrees that no relevant business needs to be addressed. Such cancellation shall be documented by the RSO.

2.3 (RESERVED)

2.4 Environmental Health and Safety Office

The Environmental Health and Safety Office, within the University Risk Management Program, is assigned the responsibility for surveillance of departmental activities and for providing services in radiation safety in conformity with policies and standards set forth in this manual. The Environmental Health and Safety Manager is designated as the Radiation Safety Officer (hereinafter referred to as “RSO”) as required by CCR Title 17 Section 30195. The RSO evaluates Sub-License applications and maintains surveillance of all uses of ionizing radiation on the California Polytechnic State University Campus.

2.5 2.5 Sub-Licensee

The Sub-Licensee named on the Radioactive Material Sub-License Authorization (Form 4a) shall be responsible for using the authorized radionuclides in compliance with all applicable State of California, NRC, and University regulations. This shall include:

I. Instructing all personnel listed on the Sub-License, in good radiation safety practices, including:

A. Control and measurement of contamination.
B. Proper use of protective clothing and equipment.
C. Operating and emergency procedures specific to their tasks.
D. Proper maintenance of records on receipt, use, transfer, and disposal.

The Sub-Licensee shall provide a copy of their Sub-License (Form 4a) to each coworker and ensure that each person has received training appropriate to level of operations carried out. The Sub-Licensee must ensure that the appropriate sections of the Radiation Safety Manual and their respective Sub-License have been read by each authorized user.

II. Ensuring that only work authorized by the approved Sub-License is carried out.

III. Ensuring that operations involving radioisotopes or radiation producing machines are performed by properly trained and authorized personnel.

IV. Maintaining records of receipt, transfer current inventory, and disposal of all radioactive materials.

V. V. Maintaining records of radiation fields and contamination monitoring.

VI. Posting warning labels, guidelines, and other appropriate postings as requested by the Environmental Health and Safety Office.

VII. Notifying the Environmental Health and Safety Office of all changes in the Sub-License such as changes in location, personnel, experiments, etc.

VIII. Notifying the Environmental Health and Safety Office immediately in the case of an accident involving radiation or potential excessive exposure.

IX. Ensuring the use of personnel dosimetry and survey instruments as applicable.

Sub-Licensees who are proposed as independent users or who will supervise use of sources of radiation by others, must have minimum qualifications as follows:

A) A college degree or an equivalent in the physical or biological sciences or engineering.

B) At least twenty (20) hours of training or practical experience in the characteristics of ionizing radiation, and in radiation dose quantities, radiation detection instrumentation, and biological hazards of exposures to radiation sources to be used.

2.6 University Compliance Enforcement Policy

1. The Sub-Licensee is notified of any items of noncompliance with a request for timely correction.

2. If no correction is established, notification is sent to the Department Head by the Radiation Safety Officer / Radiation Safety Committee. A consultation is arranged with the Department Head and the Sub-Licensee, and the items of noncompliance are clarified.

3. Corrective procedures are determined with an approximate time frame for correction of items of noncompliance.

4. Upon completion of corrections for items of noncompliance, notification is sent to the Environmental Health and Safety Office.

5. A follow up inspection is performed to determine compliance and the effectiveness of any corrective actions.

6. If the Sub-Licensee remains in noncompliance, the enforcement proceeding would progress to a consultation with the President of the University, the Department Head, the Sub-Licensee, the Risk Manager, and the Radiation Safety Officer.

7. The final action would be termination of the Sub-License and operations of the Sub-Licensee. The radioactive material would be transferred to the possession of the Environmental Health and Safety Office.

Documentation of all enforcement procedures are filed at the Department Level and the Sub-Licensee's file located at the Environmental Health and Safety Office.

2.7 Records

The records maintained by the Environmental Health and Safety Office are classified

as First Class Records and are considered vital as stated in the CPSU Vital Records Protection Plan.

Authorities and References

1. Government Code 14750(b) and 14746(b)
2. Governor's Executive Order B-48-78 and CCR Title 17 Section 30293, Radiation Control Regulations.

3. LICENSE REQUIREMENTS

3.1 University Broad Scope License

The University possesses a type B broad scope license issued by the State of California, Department of Health Services in agreement with the U.S. Nuclear Regulatory Commission, which authorizes the use of radionuclides for education and research. The License can be reviewed at the Environmental Health and Safety Office. The License describes the possession limits for each radionuclide and location for use, and provides for the internal issuance of Sub-License use authorizations. Requests for amendments to the License shall be made by the Environmental Health & Safety Office after approval by the Radiation Safety Committee.

3.2 Sub-License for the use- of Radiation

Requests to utilize ionizing radiation are separated into the following categories:

(A) Non-Human Use (research and classroom)
(B) Radiation Producing Machines

Application for Sub-License and Statement of Training and Experience are required (Forms 1 & 2). All applications are to be submitted to the Environmental Health and Safety Offices Laboratory.

3.3 Sub-Licenses with Special Requirements for Classroom Radiation Use

The Sub-Licenses for use of radioactive materials for teaching or demonstration in academic courses are valid for one year only. Such applications shall be submitted for review and approval to the RSO and the Radiation Safety Committee at least two weeks prior to the commencement of the quarter in which radionuclide use is desired. An authorized Sub-License may be renewed by the RSO providing there is no change in the isotope, quantity, or procedures. The following information is required to supplement the standard Sub-License:

A. Laboratory instructor in charge.
B. Names and history of experience for Laboratory or teaching assistants involved in the course.
C. Duration of course (i.e. 1 quarter, 1 year)
D. Number of students anticipated.
E. Number of Laboratory sections.
F. Number of students per Laboratory section.
G. Number and type of monitoring instruments needed for routine use in the Laboratory.

H. Descriptions of Proposed use and procedures for each isotope stated on the application, including:
   1) Radiation Safety instruction for students; and
   2) Extent to which students will be handling isotopes.

3.4 Submission of Sub-License Applications for Approval

The completed application shall be routed through the applicants' department chairperson for signature and then to the RSO who will transmit the application to the Radiation Safety Committee including an Application for Sub-License (Form 1), Statement of Training and Experience (Form 2), and safety protocols.

3.5 Approval of Sub-License Applications

Prior to use of radionuclides or radiation producing machines all applications must be approved by the RSO and the Radiation Safety Committee. Hazard rating categories are based on the criteria listed below. All radiation safety costs shall be borne by the researcher. Such costs shall include:

A. New construction or major alterations;
B. Acquisition of special monitoring equipment;
C. Off-campus waste disposal as determined by the Environmental Health and Safety Office , and the Radiation Safety Committee.

3.6 Methods of Computing Hazard Rating

Used for evaluating, approving, amending, and renewing of Sub-Licenses by the RSO and the Radiation Safety committee.

Hazard Ratings are computed by the formula:

$$HR = QUA/T$$

where:

Q = Quantity of radionuclide in micro-curies
U = Use factor
A = Assessment factor
T = Tolerance Factor

Table 3.1
Hazard Ratings and Reviews Required

Hazard Rating	HR Category	Review Required by the Radiation Safety Committee
100 or less	1	RSO only
101 to 1000	2	Plus chairperson of RSC
over 1000	3	Full RSC Committee

Quantity

The quantity of the radionuclide is expressed in micro-curies (1.0 E-6 curies). A micro-curie is defined as that quantity of radionuclide that decays at a rate of 3.7 E4 disintegrations per second.

Use Factor

The use factor is based on the type of experimental procedures that will be involved in the proposed use of radionuclides). Consideration is given to the probability of:

a) release of the radionuclide to the environment,
b) contamination of persons engaged in the operation;
c) contamination of equipment and facilities; and
d) external radiation hazard potential.- Examples of use Sectors are shown in table 3.2 table below.

Table 3.2
Use Factors for Various Operations

Type of operation	Use Factor
Moisture Density Probes	0.0001
Sealed Sources	0.001
Storage	0.01
Simple Wet Operations i.e. RIA Kits, Electrophoresis, Nick Translation, Chromatography	0.1
Simple Dry Operations i.e. Transfer of Dry Precipitates	1.0
In-vivo Works Radio-labeling, Work with Volatile Components	1.0 - 5.0
Complex Wet Operations i.e. Evaporation to Dryness, Aerosols	5.0 - 10.0
Complex Dry Operations i.e. Crushing, Mixing, Sieving	10.0 100.0

Assessment Factor

The assessment factor may range from 1.0 to 10.0 depending on investigation of the project and review of the performance and compliance record. The value will be recommended by the RSO prior to submission to the Radiation Safety Committee for review. 1 to 10 is equivalent to the of time operating in non-compliance. For example 12 monthly surveys, 6 months of operation in non-compliance, 6/12 = 50% or an assessment factor of 5. New Sub-Licenses will be assigned an assessment factor
of 1.

Tolerance Factor

The tolerance factor is based upon the micro-curie amounts established for each radioisotope listed in the CCR, Title 17, Section 30356, Appendix B. For radioisotopes not listed, the tolerance factor shall be determined by the RSO. See the appendices for a copy of this table

3.7 Renewal of Radioactive Material Sub-Licenses

Sub-Licenses are approved for a maximum of one year.

A. The Sub-License must be renewed annually if:
1) Work with radionuclides is to continue;
2) Any radioisotopes are to remain in possession of the applicant.

B. Renewals are reviewed by the RSO and transmitted to the Radiation Safety Committee for approval

Renewal procedures will be initiated by the RSO sending the Sub-Licensee the Notice of Expiration of Approval of Radiation Use (Form 3) prior to the expiration date of the Sub-License.

3.8 Amendments to the Sub-Licenses

All amendment requests must be submitted in writing to the RSO using the Radioactive Material Sub-License Application for Amendment (Form 5).

A. Amendment Approvals by the RSO

The RSO may authorize minor amendments to existing Sub-Licenses. Such amendments will be limited to increases in amounts of already authorized materials and locations or techniques, provided such changes do not increase the over all authorized Hazard Rating Category. Amendments involving the addition of new radioisotopes to the Sub-License may be approved by the RSO providing the amounts, use, and toxicity of the

radioisotopes added do not increase the Hazard Rating category or exceed the criteria specified by committee approval.

B. Amendments Requiring Committee Approval

Amendments to existing authorized projects must be approved by the Radiation Safety Committee if the changes involve an increase in the Projects overall Hazard category. Existing hazard rating 3 category authorizations requesting amendments shall require Radiation Safety Committee review if the total hazard rating increase for the addition of new radionuclides is >1000 or >5000 for existing radionuclides.

3.9 Termination of Sub-Licenses

Any applicant found to be willfully or negligently violating any of the CPSU, State, or NRC regulations governing the use of radionuclides may have their Sub-License suspended or revoked by the RSO with concurrence of the Radiation Safety Committee, and any radionuclides in their possession will be transferred to the possession of the Radiation Safety Officer. The applicant has the right to appeal this decision to the Radiation Safety Committee.

Sub-Licenses will ordinarily be terminated upon:
a) completion of project;
b) expiration of Sub-License without renewal.

Upon termination of a Sub-License, al] radionuclides acquired thereunder must be accounted for to or by the RSO. Unused amounts must be transferred to another active Sub-License or disposed of as Radioactive Waste.

3 10 Extended Campus Leave by Sub Licensee

An applicant leaving the campus for an extended period of time must terminate their Sub-License and dispose of the radionuclides under their control, or request an amendment to the Sub-License to allow a responsible person to assume control.

3.11 Equipment and Facilities

Laboratories are restricted to set quantities of radionuclide usage. The degree of restriction is based on the hazard rating of each Sub-License, the nature of the containment facilities, and the Laboratory design.

In some cases, specialized equipment will be necessary to assure a safe operation. CPSU has established a laboratory classification system based on the Sub-License Hazard Rating criteria that outlines minimum facility requirements.

Laboratory Classification System

The criteria listed in table 3.3 will be used to determine the laboratory assignment:

Table 3.3
Lab Classification

Hazard Rating of Isotopes	Laboratory Classification
100 or less	Class A
101 to 50,000	Class B
50,000 to 100,000	Class C
over 100,000	Class D

In this case, the Hazard Rating is applied to the individual isotope, not the cumulative rating of all isotopes authorized, unless isotopes are used in combination for a specific experiment.

Classification for Laboratories

Class A laboratories shall meet the following requirements:

a. Ten air changes per hour.
b. Smooth decontaminable floors and work surfaces.
c. Plastic backed absorbent coverage of all work surfaces.
d. Door must have a lock.
e. Available survey instrument or counting device.

Class B laboratories shall be equipped with:

a. All items listed in “Class A” above.
b. A fume hood approved by the Office of Environmental Health and Safety, minimum face velocity of 100 linear feet per minute or greater (higher velocities may be required).
c. Assigned portable survey meter or counting device.

Class C laboratories shall be equipped with:

a. All items listed in “Class A and B.” above.
b. An approved glove box maintained under negative pressure.

Class D laboratories shall be equipped with:

a. All items listed in Class A, B and C above.
b. An approved shielded glove box with remote manipulators.
c. Exhaust stack monitor.
D. Lead glass shields.
e. Strippable floors.
f. Air monitoring capability.
g. Hand and foot counters.
h. Separate waste storage area.
i. Continuous background monitor.

3.12 Exceptions to Facilities Criteria

Exceptions to the above requirement may only be granted by a majority of a quorum of the Radiation Safety Committee.

3.13 Building Plans

Plans for new buildings or for alterations in existing buildings, where provisions are made for use or possible use of radionuclides or radiation producing machines, shall be reviewed by the Radiation Safety Officer. The Radiation Safety Officer is responsible for obtaining further review and approval by the Radiation Safety Committee and others, as circumstances dictate.

3.14 Relocations

The relocation of radionuclides to areas other than those stated in the Sub-License must have prior approval by the RSO.

4. ACQUISITION, TRANSFERS, AND DISPOSAL

4.1 Procurement Policy

All purchases of radioactive materials shall be accomplished through established campus purchasing channels and with the approval of the Environmental Health and Safety Office.

4.2 Purchasing Procedure

Purchases shall be requested on standard purchase requisition forms and the Radioactive Materials/Radiation Machine(s) Purchase Endorsement (Form 6):

A. Indicate the identity and amount of radioactive material desired.
B. A copy of the Sub-License.
C. Indicate any special instructions for shipping and handling.
D. Indicate that material is to be delivered to the Environmental Health and Safety Office , unless otherwise approved by the RSO.
E. Send the requisition to the Environmental Health and Safety Office for approval and forwarding to the Purchasing Department.

Purchase endorsements will not be approved if the requested radionuclides and amounts are not identified on the Sub-License.

4.3 Delivery of Radionuclides

Receiving Procedures are as follows:

1. Radioactive Materials are received at the CPSU warehouse and at the CPSU Foundation Receiving Department.

2. Upon receipt of any radioactive materials bearing the U.S. Department of Transportation labels (White I or Yellow II or Yellow III) and a corresponding Transport Index (1 to 10), the RSO is notified.

3. The Radiation Safety Personnel Perform a visual inspection of the package to evaluate the condition of the shipping container and a radiation survey is performed.

4. Shipping receipts or bills of lading are checked to verify contents.

5. The package is opened and the radioactive material is surveyed to determine radiation levels. The source is leak-tested if required. The package is then delivered by the Radiation Safety Personnel to the Sub-Licensee.

6. Upon completion of checking the package containing radioactive material, the material then becomes the responsibility of the Sub-License. The Sub-Licensee is responsible for the safe use and storage as required. Form 7 & 8 are used to document surveys, inspection of packages, and quality Control.

7. Should any radioactive material arrive over the weekend or at night, the University Police are instructed to receive it unopened and place it in the Environmental Health and Safety Office until the RSO is notified.

4.4 Custody of Radioactive Materials

The users named on the Sub-License shall be continuously responsible for the custody of any radioactive material acquired under the Sub-License. They shall be responsible for the proper storage, labeling, inventory, accounting, use, and disposal of the material.

4.5 All Shipments of Radioactive Material Must Be Specifically Approved by the RSO

All packaging and labeling of shipping containers must conform to the Department of Transportation regulations and any other appropriate regulations. The Environmental Health and Safety Office must be consulted for the appropriate regulations prior to shipping.

After proper packaging and approval, shipments shall be made through the State Warehouse or the Foundation Warehouse Shipping and Receiving.

Special arrangements may be made with the RSO where applicable control shipments are made by outside professional agencies or Institutes.

Improper packaging, labeling, and certification can result in a monetary fine from the Department of Transportation as well as a citation from the State Department of Health Services.

4.6 Transfer of Radioactive Materials

A. Radioactive materials shall not be transferred from any person, department, or project to another without specific, prior approval of the RSO. Unauthorized transfer of radioactive materials may result in the revoking of the Sub-License and removal of the material. Radioactive Sub-License

Application for Amendment and Amendment Approval (Forms 5 and 5a) shall accompany all transfers.

B. Transfer of Radioactive Material Between Campuses.

Transfer of radioactive materials to another campus, within the California State University system shall need prior approval from the RSO and the Radiation Safety Officer on the campus to which the material is transferred. Shipping procedures shall comply with all Department of Transportation regulations.

C. Transfer to a Nuclear Regulatory Commission (NRC) Licensee or State Licensee.

An individual desiring to transfer radioactive materials to another NRC or State Licensee shall have specific prior approval from the RSO. The RSO shall be responsible for determining if the recipient is authorized to receive and possess the material to be shipped and for securing a copy of the recipients applicable License. The shipping procedures shall comply with the Department of Transportation regulations.

4 7 Semi-Annual Radioisotope Inventory

Twice a year, the RSO shall mail to the Sub-Licensee an inventory printout for each Sub-License which tabulates the Radionuclides received and on hand. It is the responsibility of each Sub-Licensee to review the current inventory and notify the RSO of any changes.

4.8 Radioactive Waste Disposal Policy

All potentially contaminated material must be disposed of as radioactive waste.

Radioactive waste must be stored in approved containers and sealed prior to pickup by the Radiation Safety Staff.

ALL containers must be labeled with a “Caution (or Danger)-Radioactive Materials” label indicating the isotope(s), amount (activity), and date of assay.

Liquid waste containers shall additionally identify the chemical composition present.

The Sub-Licensee is responsible for verifying the chemical compatibility of all solutions placed in the liquid waste container.

No Sub-Licensee- will be authorized by the Radiation Safety Committee to generate radioactive waste unless provisions are in the research grant or

department funding to pay for off campus waste disposal. See section 4.11 on how to deal with Off Campus Waste Disposal.

4.9 Radioactive Waste Containers

ALL radioactive waste material shall be contained as follows:

A. **Dry Waste**:

- o All dry waste must be deposited in a two-cubic foot box or another container approved by the Environmental Health and Safety Office
- o Each box must be lined with a clear plastic bag.
- o Vials containing liquid are not to be discarded into the dry waste.
- o Needles must be placed in an impermeable, approved sharps container prior to being placed into dry waste.
- o Short radiological half-life radionuclides (half-life of less than 90days) shall be segregated.
- o Radioactive labels shall be defaced prior to putting them in the dry waste.

B. **Aqueous Liquid Waste Only**: Absorbed liquid waste shall be put into 1 gallon jugs or other suitable intermediate containers approved by the Environmental Health and Safety Office. Short-life radionuclides with a physical half-life of less than 90 days shall be segregated.

C. **Scintillation Vials**: Full vials are to be placed in the original honeycomb containers in which they were received.

D. **Animal Carcasses**: Individual researchers shall have access to freezer storage for animal carcasses with the scheduled waste collection date. Notify the Environmental Health and Safety Office when you have animal carcasses for disposal.

Special arrangements for disposal of large animal carcasses must be made with the Environmental Health and Safety Office prior to administering radioactive materials.

4.10 Disposition of Radioactive Waste

All waste will be picked up by the Environmental Health and Safety personnel. The containers must be properly labeled and sealed. Twenty-four (24) to forty-eight (48) hour notification should be given to allow time for pickup of containers.

A. Disposal through the Sanitary Sewer.

Disposal of liquid radioactive waste through the sanitary sewer system is prohibited unless specifically approved by the Radiation Safety Committee.

B. Disposal by Burial.

Disposal by burial on site is prohibited.

C. Unusual Radioactive Waste Disposal Problems.

The RSO and Radiation Safety Committee will assist in the development of disposal for unusual wastes or wastes with off-normal composition or configuration. The method must be developed and defined on the Sub-License.

4.11 Off Campus Waste Disposal

All Radioactive waste will be collected by the Environmental Health & Safety Office from individual laboratories where waste is generated by the Sub-Licensees. These wastes shall be stored in the central Radioactive Waste Storage facility located at the Radiation Safety laboratory. The Radioactive Waste Storage Building is locked and only authorized personnel are allowed access.

When stored radioactive waste accumulates enough to warrant off campus disposal the packaging and shipping shall be done by Environmental Health and Safety or an authorized Radioactive Waste contractor.

No Sub-Licensee will be authorized by the Radiation Safety Committee to generate radioactive waste unless provisions are in the research grant or department funding to pay for off campus waste disposal.

5. EXPOSURE STANDARDS AND DOSIMETRY

5.1 Radiation Exposure Goals

The California Polytechnic State University goal is to maintain human radiation exposure levels to as low as reasonably achievable (ALARA). The annual exposure limits for personnel over the age of 18 years are shown in table 5.1.

Table 5.1 - Annual Limits

Total Effective Dose Equivalent (TEDE)		5 rem (0.05 Sv)
Sum of the Deep Dose (H_d) and Committed Dose Equivalent (CDE, H_{T-50}) to any Individual Organ or Tissue (expect the lens of the eye)		50 rem (0.5 Sv)
Lens of the Eye (LDE)		15 rem (0.15 Sv)
Skin (Shallow Dose, H_s)		50 rem (0.5 Sv)
Extremities		50 rem (0.5 Sv)

The administrative goals for annual exposure are shown in table 5.2.

Table 5.2 - Administrative Goals for Annual Exposure

Total Effective Dose Equivalent (TEDE)		3 rem (0.03 Sv)
Sum of the Deep Dose (H_d) and Committed Dose Equivalent (CDE, H_{T-50}) to any Individual Organ or Tissue (expect the lens of the eye)		10 rem (0.1 Sv)
Lens of the Eye (LDE)		5 rem (0.05 Sv)
Skin (Shallow Dose, H_s)		10 rem (0.1 Sv)
Extremities		10 rem (0.1 Sv)

The annual exposure limits and administrative goals for a person under the age of 18 years (a minor) are shown in table 5.3.

Table 5.3 - Annual Exposure Limits and Administrative Goals for Minors

		Limit	Goal
Total Effective Dose Equivalent (TEDE)		0.5 rem	0.4 rem
Sum of the Deep Dose (H_d) and Committed Dose Equivalent (CDE, H_{T-50}) to any Individual Organ or Tissue (expect the lens of the eye)		5 rem	4 rem
Lens of the Eye (LDE)		1.5 rem	1 rem
Skin (Shallow Dose, H_s)		5 rem	4 rem
Extremities		5 rem	4 rem

The exposure limit for an embryo / fetus, due to tasks or activities performed by a declared pregnant woman as described in or permitted by the license or any sub-license, shall not exceed 0.5 rem (500 milli-rem) during the entire pregnancy.

The Radiation Safety Officer or Sub-licensee shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman so as to satisfy the limit of 500 milli-rem.

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

A. The deep-dose equivalent to the declared pregnant woman; and

B. The dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman.

If the dose to the embryo/fetus is found to have exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licensee shall be deemed to be in compliance with paragraph (a) of this section if the additional dose to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.[4]

5.2 Compliance With Exposure Limits and Goals

Each adult receiving occupational exposure shall be provided with an individual monitoring device, and shall be required to use that device, if it is likely that the individual will exceed 10% of the applicable annual exposure limit listed in Table 5.1. Individual monitoring devices include film badges, TLDs, electronic or other self reading dosimeters, air samplers and similar devices.

The exposure determined from the processing of film badges or TLDs, or recorded by electronic or other self reading dosimetry will be considered as deep and / or shallow dose. Deep and shallow dose components of exposure will be specified on dosimetry processor documentation as applicable or as requested.

Limits For Sources of Non-Occupational External Exposure

Each sub-licensee shall conduct their operations such that:

1. The total effective dose equivalent (TEDE) to individual non-radiation workers or other members of the public will not exceed 100 milli-rem in one year.
2. The dose in any unrestricted area from external sources does not exceed 2 milli-rem in any one hour.

3. If members of the public are permitted access to areas controlled for the purposes of radiation protection, the member of the public dose limits (i.e. non-occupational limits) continue to apply.

Limits for Sources of Internal Exposure

An occupationally exposed individual will be within the limits specified in table 5.1 if in the absence of external exposure, that individual has been exposed to fewer than 2000 DAC-hours of total airborne radioactivity, or by assay of internally deposited radioactive material, is determined to have intakes less than the appropriate ALI.

An occupationally exposed individual will be within the goals specified in table 5.2 if in the absence of external exposure, that individual has been exposed to fewer than 400 DAC-hours of total airborne radioactivity, or by assay of internally deposited radioactive material, is determined to have intakes less than 0.2 times the appropriate ALI.

Internal dose (organ dose or tissue dose) may be calculated in several ways:

1. An analysis of airborne radioactive material may be performed. The concentration of each radionuclide determined to be present is compared to that radionuclide's tabled derived air concentration (DAC) value. The sum of the ratios (radionuclide concentration present ÷ radionuclides DAC value) will yield the DAC present. Multiplying the DAC present by the time of exposure, in hours, yields DAC-hours. Note that the actual airborne concentration may be divided by the protection factor of any respiratory protective device used to estimate the concentration to which the individual was exposed.

Each DAC-hour is equal to approximately 2.5 milli-rem committed effective dose equivalent (CEDE). An individual may receive 2000 DAC-hours in a year without exceeding the limits due to internal exposure alone[5].

2. Bioassay assessment may be performed to estimate the activity of radionuclides present in the body following internal deposition of radioactive material. Each radionuclide present is compared to that radionuclides annual limit on intake (ALI). One ALI is assumed to be equivalent to 50 rem committed dose equivalent (CDE) or to 5 rem committed effective dose equivalent (CEDE). Multiplying the fraction of ALI by the dose limit (50 rem CDE or 5 rem CEDE) yields the value of the exposure.

The Summation of Internal and External Exposures - Total Effective Dose

Equivalent (TEDE)

A shown in tables 5.1 - 5.3, the total effective dose equivalent consists of the sum of external, deep dose and internal dose.

If the licensee is required to monitor both external *and* internal exposure, and the individual is deemed by the Radiation Safety Officer or the Radiation Safety Committee to be likely to exceed 10% of the applicable annual limit for external exposure *and* internal exposure, compliance with the dose limits shall be demonstrated by summing external and internal doses.

Compliance can be demonstrated for summation of external and internal doses if required, by adding the individual's deep dose and the summation of any calculated committed effective dose equivalent (CEDE) values.

If monitoring is required for only external *or* internal exposure, but not both, then summation is not required to demonstrate compliance with the dose limits.

(Note: The dose equivalents for the lens of the eye, the skin, and the extremities are not included in the summation, but are subject to separate limits.)

Intake by oral ingestion: If an occupationally exposed individual also receives an intake of radionuclides by oral ingestion *and* that intake is greater than 10% of the applicable oral ALI, the exposure shall be accounted for in demonstrating compliance with the limits.

Intake through wounds or absorption through skin: If appropriate or necessary, intakes through wounds or skin absorption will be evaluated to account for any exposure. (Note: The intake through intact skin has been included in the calculation of DAC for hydrogen-3 and does not need to be further evaluated.)

5.3 Dosimetry

The Environmental Health and Safety Office will distribute dosimetry in the form of film badges, TLD's, and self reading Dosimeters to personnel to aid in the assessment of radiation exposure. Dosimetry shall be issued only when careful evaluation establishes a need for the use of this monitoring technique.

These devices provide legal records of radiation exposure, therefore, it is imperative that they only be used as prescribed. When prescribed, they must be worn at all times while working with radionuclides or radiation producing machines. They must be stored away from radiation sources and protected against heat, moisture, or contamination.

Film badges and TLD's are returned to Environmental Health and Safety and are processed at predetermined intervals. The California Code of Regulations

requires that personnel be supplied with and use film badges or other approved personnel monitoring devices, if they enter a radiation controlled area under such circumstances that they are likely to receive more than 10 percent of the appropriate annual exposure limit as specified previously. For persons 18 years of age or older, 10 percent of the external, deep dose limit for the whole body is 500 milli-rem per year, and for persons under 18, 50 milli-rem per year.

Film badge dosimeters, issued when monitoring is required, should normally be changed at quarterly intervals in cases where radiation exposure is likely to be nominal.

5.4 Personnel Exposure Records

Personnel exposure data shall be part of the permanent records of Environmental Health and Safety Office including Radiation Exposure Record (Form 10, 10A and/or 10B), TLD Ring Exposure Record (Form 11), and any related documents furnished by outside contractors for fiIm badges and TLD rings. Upon written request by any employee or student, Environmental Health and Safety will provide a copy of the individuals exposure history. In addition, in any case where exposures of an individual to radiation must be reported to the NRC and/or the State Department of Health Services pursuant to regulations, such individuals will be notified in writing of the nature and extent of their exposure.

Records of Prior Exposure

Employees or students requiring continuous personnel dosimetry will be required to complete Exposure History (Form 14) indicating all locations where previous radiation exposures may have occurred during the current year. An attempt will be made to obtain records of previous, cumulative occupational exposure. When requests for records are made, such requests will begin with the signed consent of the individual.,

In complying with the requirements in the above section, the Environmental Health and Safety Office may:

(1) Accept, as a record of the occupational dose that the individual received during the current year, a written signed statement from the individual, or from the individual's most recent employer for work involving radiation exposure, that discloses the nature and the amount of any occupational dose that the individual may have received during the current year;

(2) Accept, as the record of cumulative radiation dose, an up-to-date NRC Form 4, or equivalent, signed by the individual and countersigned by an appropriate official of the most recent employer for work involving radiation

exposure, or the individual's current employer (if the individual is not working within this license); and

(3) Obtain reports of the individual's dose equivalent(s) from the most recent employer for work involving radiation exposure, or the individual's current employer or current license holder (if the individual is from another site or worked within the scope of another license) by telephone, telegram, electronic media, or letter. The licensee shall request a written verification of the dose data if the authenticity of the transmitted report cannot be established.

The licensee shall record the exposure history of each individual, considered likely to exceed 10% of the applicable limits in table 5.1, on NRC Form 4, or other clear and legible record, including all of the information required by NRC Form 4 (Note: It is not required to partition historical dose between external dose equivalent(s) and internal committed dose equivalent(s). Further, occupational exposure histories obtained and recorded on NRC Form 4 or equivalent records before January 1, 1994, might not have included effective dose equivalent, but may be used in the absence of specific information on the intake of radionuclides by the individual).

The form or record must show each period in which the individual received occupational exposure to radiation or radioactive material and must be signed by the individual who received the exposure. For each period for which the licensee obtains reports, the licensee shall use the dose shown in the report in preparing the NRC Form 4. For any period in which a report can not be obtained, the licensee shall place a notation on the NRC Form 4 indicating the periods of time for which data are not available.

If the licensee is unable to obtain a complete record of an individual's current and previously accumulated occupational dose, the licensee shall assume for the purpose of establishing administrative controls for the current year, that the allowable dose limit for the individual is reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual was engaged in activities that could have resulted in occupational radiation exposure.

The records will be retained on NRC Form 4 or equivalent until the termination of the license requiring this record.

Those records used in preparing NRC Form 4 will be retained for 3 years after the record is made. This includes records required under the standards for protection against radiation in effect prior to January 1, 1994.

5.5 Medical Surveillance Policy

Personnel will be placed under medical surveillance when their potential exposure to ionizing radiation is such that somatic biological effects susceptible to detection by a medical evaluation could occur. Such appraisal will include an acute and chronic exposure evaluation and will consider many variables (duration, source, type of potential exposure, etc.). Personnel shall be referred as follows

A. Employees:
   Employees requiring medical surveillance will be included in the campus medical monitoring program, at no cost to the employee..

B. Students:
   Students requiring medical surveillance because of potential radiation exposure during academic pursuits will be referred to the Student Health Center for examination.

Refusal to obtain required medical surveillance can result in suspension of authorization to work with radioactive materials

5.6 Examinations of Potential or Actual Uptakes of Radioactive Material

Examinations and evaluations will be conducted and/or coordinated by the Environmental Health and Safety office when it is known or suspected that an individual has received an uptake of radioactive material.

The following records will be generated and maintained, as applicable, to document the an evaluation:

I. Any measurement made to detect internally deposited radioisotopes
II. Information necessary to assess exposure
III. Personnel dosimetry records

It is the policy of CPSU to qualitatively and quantitatively assess and estimate internally deposited radionuclides.

Examinations will be made of any student or employee who has been deemed likely to exceed 0.1 ALI of any single radionuclide or combination of radionuclides through ingestion, inhalation, or absorption through the skin or through wounds. Urine analysis, thyroid counting, whole body counting, and eye examinations may be included in an evaluation of an actual or suspected uptake. Radiation workers shall be scheduled at a prearranged time for such measurements.

Copies of medical examination records for students, staff, and faculty will be maintained in the Student Health Center and will be coordinated with personnel dosimetry data, at The Environmental Health & Safety Office.

5.7 Dosimetry and Bioassay

Bioassay and other internal dose assessments techniques should be initiated in all cases where it is known or suspected that an individual has received an uptake of radioactive material in excess of 10% of the applicable ALI for any single radionuclide or mixture of radionuclides.

Individuals under the age of 18 are subject to lower limits. Therefore, bioassay and other internal dose assessments techniques should be initiated in all cases where it is known or suspected that an individual minor has received an uptake of radioactive material in excess of 1% of the applicable ALI for any single radionuclide or mixture of radionuclides.

Tritium

There are three types of bioassay programs applicable to individuals working with tritium. They are **routine**, that is established prior to the work beginning and continuing at regular intervals until terminated by the Radiation Safety Committee, Radiation Safety Officer, or the Environmental Health and Safety Office, **special**, which is set up to monitor high risk tasks or accidents, and **confirmatory**, which is employed where the risk of tritium intake is small but not non-existent.

A **routine** bioassay program will be established for any sub-licensee using tritium when an individual intake of 2.7 E^3 μCi (2.7 milli curies) or greater is considered likely by the Radiation Safety Committee, the Radiation Safety Officer, or the sub-licensee.

A **routine** bioassay program will be established for any sub-licensee using tritium when worker intakes or air concentrations of tritium cannot be reliably predicted and the following tritium concentrations or quantities and processes (operations) (Table 5.4) exist:

Table 5.4[6]
Processes and H_3 Activities Requiring a Routine Bioassay Program

Type of Operation	Tritium and Tritiated Organics Including DNA precursors	Tritium Gas in Sealed Process Vessels	Tritium mixed with more than 10 kg of inert Water or Other Material
Processes in open room on bench top	0.1 Curie (100 milli Curie)	100 Curies	10 milli Curies/kg
Processes in a fume hood with adequate face velocity and performance reliability	1 Curie	1000 Curies	100 milli Curies/kg
Processes in a glove box	10 Curies	10,000 Curies	1 Curie/kg

A **routine** bioassay program will be established for any sub-licensee using tritium when tritium could be taken up through the skin in quantities exceeding 100 μCi in a two week period.

Pregnant workers will participate in a **special** bioassay program when working with tritium and an intake of 320 μCi or greater could occur.

A **special** bioassay will be required if assigned tasks or accidents could result in individual intakes of 3,200 μCi or greater in any two week period.

A **confirmatory** bioassay program will be administered at the discretion of the Radiation Safety Committee, Radiation Safety Officer, or Environmental Health and Safety Office. This type of program will typically rely on random samples from selected sub-licensees or on the analysis of data generated in routine or special bioassays.
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For tritium monitoring, the most useful bioassay procedure utilizes the collection and assay of urine. Urine analysis is performed by the following procedure:

1. At the start of working with the radioactive material the user will collect a 24 hour urine sample and record the volume in milliliters. A 24-hour urine sample will be collected every 6 months there after or if there is any change in eating, drinking, or health conditions.

2. The specific density is determined by the use of a urinometer. The specific density of urine in grams/ml is used to calculate the total 24 hour urine mass:

   Grams/ml (Urine) / ml (in 24 hours) = total grams of Urine

3. One (1) milliliter of urine is pipetted into a counting vial.

4. Ten (10) milliliters of scintillation mixture is added to the vial.

5. The vial is counted in the LS-100 Liquid Scintillation Counter.

6. For Calibration of the LS-100 see the Technical Capabilities manual for "Tritium and C-14 Determination with the Liquid Scintillation Counter".
7. Alternatively, the sample may be sent to an accredited laboratory facility for counting and analysis.

Using Spot Bioassay Data (Form 15), record the concentration (dpm/ml) as determined by Liquid Scintillation Counting.

Since tritium is assumed to distribute rapidly throughout the body's water, the dpm/ml value can be used as a direct measure of tritium present in the body at the time of sampling.

To estimate total body activity, multiply dpm/ml by 42,000 ml, total body water (men) or 34,000 ml (women). These total body water values are estimates based on ICRP 23, Reference Man data[7]. Other values which better approximate an actual individual may be used in their place. These values are, however, considered appropriate for most cases.

For tritium, the Committed Effective Dose Equivalent (CEDE) per dpm/ml of tritium in urine is tabled below.

Table 5.5
CEDE per dpm/ml, Tritium in Urine
(ALI=1.776 E11 dpm OR 80,000 μCi)

Total Body Tritium Activity (dpm/ml_{Urine} * Total Body Water)	Activity in μCi	Fraction of Tritium ALI	CEDE Dose in mrem (50 year integrated dose, reported in year of uptake)
500	2.25E-4	2.82E-9	1.41E-5
1000	4.50E-4	5.63E-9	2.82E-5
5000	2.25E-3	2.82E-8	1.41E-4
10,000	4.50E-3	5.63E-8	2.82E-4
50,000	2.25E-2	2.82E-7	1.41E-3
100,000	4.5E-2	5.63E-7	2.82E-3
500,000	2.25E-1	2.82E-6	1.41E-2
1,000,000	4.50E-1	5.63E-6	2.82E-2
5,000,000	2.25	2.82E-5	1.41E-1
10,000,000	4.50	5.63E-5	2.82E-1
50,000,000	2.25E+1	2.82E-4	1.41
100,000,000	4.50E+1	5.63E-4	2.82
500,000,000	2.25E+2	2.82E-3	14.1
1,000,000,000	4.50E+2	5.63E-3	28.2
5,000,000,000	2.25E+3	2.82E-2	141
10,000,000,000	4.50E+3	5.63E-2	282
17,800,000,000 (0.1 ALI)	8.00E+3	1.00E-1	500

Iodine

Bioassays shall be performed within 72 hours of primary use for persons using iodine 125 or 131 in unsealed form it the quantity handled at any one time or cumulatively over a month's period is 10 milli-curies or more in a volatile form, or 100 milli-curies or more in a form which is chemically bound and processed in such a manner that the Iodine remains in a nonvolatile form.

Phosphorus And Sulfur

Bioassays shall be performed within one week of primary use for persons using radioactive materials P-32 or S-35 in unsealed form if the quantity handled at any one time or cumulatively over a month's period is 100 milli-curies or more.

Additional Requirements

Bioassays shall be performed following an incident which might cause an individual to receive an uptake of the limits specified in Condition(s) 1, 2, 3, and/or, 4 below.

1. Iodine-125 and/or 131 shall not be used in such a manner that the thyroid uptake exceeds 3.0 micro-curies in any year. This is based on 0.1 ALI of the more restrictive radionuclide (I-131) and would be equivalent to 5 rem thyroid CDE or 150 milli-rem CEDE.

2. Phosphorus-32 shall not be used in such a manner that an uptake could exceed 60 micro-curies in any year. This is based on the ALI for oral ingestion and would be equivalent to 500 milli-rem CEDE.

3. Sulphur-35 shall not be used in such a manner that the whole body uptake exceeds 600 micro-curies (0.6 milli-curies) in any calendar quarter. This is based on 0.1 ALI and considers the non-stochastic limit for the Lower Large Intestine (LLI). This 600 micro-curies would be equivalent to 300 milli-rem LLI CDE and 500 milli-rem CEDE.

4. Licensees will use, control, possess and transfer any other radioactive material in such a manner that uptakes do not exceed 10% of the more restrictive ALI value tabled for that radionuclide. For mixtures of radionuclides, licensees will use, control, possess and transfer those mixtures such that the sum of the fractions of each uptake quantity divided by the more restrictive ALI does not exceed 0.1.

Notwithstanding the section above, a licensee may be issued prior, specific authorization to conduct activities which may result in uptakes of greater than 10% of the applicable ALI providing that:

1.) The Total Effective Dose Equivalent (TEDE), that is the sum of all internal committed effective dose equivalents (CEDE) and external, deep dose will not exceed 5 rem for the year, and,
2.) No organ or tissue exceeds its applicable Committed Dose Equivalent (CDE) limit.

Specific, prior authorization may be granted by the Radiation Safety Committee after the sub-licensee has submitted an acceptable monitoring plan which includes provisions for bioassay.

A complete listing of radionuclides and their DAC and ALI values is contained in **Appendix 8**.

5.8 Excessive Radiation Exposures

The RSO must be notified immediately if any person is known or suspected of receiving internal or external exposure to radiation in excess of the limits specified in table 5.1. Such persons will be placed under competent medical care at once.

6. RADIATION PROTECTION REQUIREMENTS

6.1 Inventory of Radioactive Materials/Leak Tests

A central inventory of radioactive material on campus is maintained by the RSO. Each user must keep reasonable records of the amounts and kinds of radioactivity under his supervision so that the central inventory may be updated. Leak tests of sealed sources shall be done by the RSO or designee, in accordance with 17 CCR 30275, twice yearly on sources other than those listed in table 6.1.

Table 6.1
Sources Exempted From Twice Yearly Leak Testing

Tritium (H-3)
Krypton-85 (Kr-85)
Source Material
Sources containing radioactive material with a half life of **30 days or less**
Sources of **beta and/or gamma** emitting radioactive material with an activity of **100 micro-curies** or less
Sources of **alpha and/or neutron** emitting radioactive material with an activity of **10 micro-curies** or less
Sources of beta and/or gamma emitting radioactive material which are not in use and which are securely stored and labeled as not to be used. These sources shall be leak tested prior to returning to service.

No source will be put into use unless it has been certified by the manufacturer as having passed a leak test or a leak test has been confirmed by the Radiation Safety Officer.

Contamination and leak tests shall be capable of determining the presence of 0.005 micro-curies of removable contamination.

6.2 Storage of Radioactive Materials

Radioactive materials shall be stored so as to prevent unauthorized access or removal from their place of storage. The Storage shall not create a “radiation area” and will be shielded or sealed to keep exposures as low as reasonably achievable.

6.3 Posting and Labeling

A. Rooms in which radioactive materials are used or stored shall be posted with a sign bearing the radiation symbol and “CAUTION (or DANGER)-RADIOACTIVE MATERIAL”.

B. Areas in which there exists a radiation level in excess of 5 milli-rems per hour shall be posted with a sign bearing the radiation symbol and "CAUTION (or DANGER)- RADIATION AREA".

C. Areas in which there exists a radiation level in excess of 100 milli-rems in 1 hour at 30 centimeters (1 foot) shall be posted with a sign bearing the radiation symbol and "CAUTION (or DANGER)-HIGH RADIATION AREA

D. Containers holding radioactive materials for storage or during processing and use shall be clearly labeled with a sign bearing the radiation symbol and "CAUTION (or DANGER)- RADIOACTIVE MATERIAL", and shall state the quantities and identify the isotope and the date.

E. "Notice to Employees" State of California Form RH 2364 shall be posted permanently and conspicuously in all areas where work with radioactive materials or radiation producing machines is being carried out.

6.4 Protective Clothing

Personnel working with open sources of radioisotopes must wear protective garments. Open-toed shoes and sandals are not permitted. The usual laboratory coat and disposal gloves are considered minimum fulfillment of this requirement. Persons working with greater than 1 mCi of an open source of radioactivity must cover their legs with pants or garment to protect them against absorption of radioactivity in the case spill. Additional protective garments may be required by the RSO. Exceptions may be granted by the RSO and the Radiation Safety Committee.

6.5 Storage and Consumption of Food and Smoking

The storage and consumption of food and smoking are prohibited in locations authorized for the storage and use of radioactive materials except in designated "clean areas." Upon the request of the Principal Investigator/Sub-Licensee, clean areas will be posted by the Environmental Health and Safety Office after a critical evaluation of the potential for maintaining the area free of radioactive contamination.

Approval of the "clean area" will depend in part on the radioisotopes, amounts, physical forms as well as the types of operations being conducted. For hazard rating 1 locations, approval may be given by the RSO.

Refrigerators used for storage of radioactive materials shall not be used for storage of food and beverages.

6.6 Personal Hygiene

Mouth pipetting is not permitted while working with radioactive materials. Personnel completing the manipulation of radioactive materials shall wash their hands thoroughly before leaving the laboratory.

6.7 General Monitoring

Immediately following the use of radioactive materials, the area and equipment shall be monitored for contamination and radiation fields by personnel directly involved with the project. At minimum, wipe tests must be done once every month it radioactive work has occurred. Monitoring results must be kept for inspection by Radiation Safety and by the State Department of Health Services. Documented monitoring results may be required more frequently at the discretion of the RSO and the Radiation Safety Committee.

Each Sub-Licensed facility in which radioisotopes are used shall have survey instrument(s) on hand capable of detecting hazardous levels of radiation. These instruments shall be continuously available for routine monitoring and for hazard surveys following a radiation incident. These instruments shall be calibrated annually by an accredited calibration service (or more frequently if required by the manufacturer of the instrument).

6.8 Monitoring by Radiation Safety

Radiation Safety shall conduct periodic surveys of all areas in which significant radiation may be present, and institute or recommend appropriate corrective measures in cases where contamination or other sources of potential hazards are detected.

6.9 Contamination Control Levels

The contamination control levels are listed below in table 6.2. It is the University policy however, to maintain contamination levels as low as reasonably achievable. These values reflect the results from wipe tests counted on a liquid scintillation counter, a Multi-Channel Analyzer (Nal or CaF2), or other appropriate instrument.

Table 6.2
Contamination Control Levels

Area (See Area Definitions)	**Alpha Emitters** cpm/100 cm^2	**Beta / Gamma Emitters** cpm/100 cm^2
Unrestricted	2 x background	2 x background
Semi-Restricted	2 x background	4 x background
Restricted	4x background	8 x back ground

Area Definitions:

Unrestricted Area
Any area in which the access is uncontrolled by the user for purposes of radiation safety.

Semi-Restricted Area
Any area in which access is limited to authorized persons for purposes of radiation safety. Protective clothing is required. Monitoring is required on a routine basis.

Restricted
Any area in which the access is controlled by the user for purposes of radiation safety. Protective clothing is required. Persons leaving a restricted area must monitor themselves for contamination and institute procedures to prevent the spread of contamination outside restricted areas.

6.10 Animal Use

A. Caging and Labeling

Small animals given radioactive materials shall be caged separately from non-radioactive animals. Cages shall be labeled with appropriate radiation warning signs. Information on the label shall include the name of the Sub-Licensee responsible for the experiment, the radioisotope, quantity, and date of administration. Special arrangements through Environmental Health & Safety will be required prior to relocation of any such animals.

B. Contamination Control

Radioactive excreta, animal carcasses and tissue, contaminated cage bedding, etc., must be handled in accordance with radioactive waste disposal procedures. Projects likely to produce large quantities of waste or involving unusual contamination potentials will be reviewed by the RSO prior to the start of work to assure that facilities are adequate.

C. Instruction of Caretakers

Sub-Licensees are responsible for assuring that animal caretakers and custodians are aware of potential hazards and are adequately trained and supervised in the observance of necessary precautions.

D. Sale of Experimental Animals

Sale of animals containing radioisotopes must receive prior certification from the RSO. Any undue costs will be borne by the researcher.

E. Release of Animals Containing Radioactive Material

Animals which have received radioisotopes for therapeutic or diagnostic purposes shall not be released unless:

1) They are released to an individual or organization licensed to receive the aggregate quantity of radioactive material remaining in the animal, or,

2) The aggregate quantity of radioactive material remaining in the animal does not exceed the exempt quantity and direct exposure to the animal will not result in an external dose exceeding 2 milli-rem in any one hour or 50 milli-rem in a year.

3) Exposure to external sources presented by the animal and to activity in the excreta would not result in a total effective dose equivalent (TEDE) in excess of 100 milli-rem in a year to any individual.

4) A consent form explaining the hazards and precautions must be given to the owner of the animal. The owner must understand the warning and instructions and sign the consent form prior to the administration of radioisotopes.

6.11 Safe Work Practices

A. Good housekeeping is required where radionuclides are used. Work areas must be clearly defined and uncluttered.

B. Work Surfaces shall be covered to facilitate easy decontamination. Absorbent pads and bench coverings shall be changed frequently.

C. Locate work areas away from heavy traffic or doorways.

D. When moving radioactive solutions between approved locations, place materials within secondary containers.

7. RADIATION PRODUCING MACHINES

7.1 Approval for Acquisition

Departments contemplating use of a radiation producing machine shall obtain the approval of the RSO and the Radiation Safety Committee, by applying for a Sub-License (Forms 1 and 2) and receiving appropriate Sub-License Authorization (Form 4a, 4b, 4c, 4d, 4e, or 4f).

7.2 Proposal for Use

Departments desiring to purchase or acquire radiation producing machines shall submit their application for use to the Environmental Health & Safety Office for review. The Sub-License application must include, in complete detail, the following information:

A. Name of the Sub-Licensee and extent of experience with the particular radiation producing machine requested.

B. Names of personnel who will use the machine.

C. Description of the machine and its proposed use.

D. Safety provisions which will be provided, such as shielding, equipment safety devices, and monitoring.

E. Approval of Department chairperson or dean.

F. A safety procedure specifically designed for the particular radiation producing machine shall be on file with the Environmental Health and Safety Office. Each individual assigned responsibility for operating the machine shall be thoroughly familiar with the safety protocol prior to assuming his/her duties as an operator.

7.3 Purchases

All purchases of radiation producing machines shall be made through the normal procedures of the Purchasing Department upon appropriate Purchase Endorsement approval by the RSO and the Radiation Safety Committee (Form 6).

7.4 Survey of Installation

Prior to use, installations of radiation producing machines, whether newly acquired, relocated, modified or repaired, shall be surveyed by Environmental Health & Safety in order to determine effectiveness of radiation hazard controls.

For new installations or modifications of existing sites, submit a Request for Shielding Evaluation to the Environmental Health and Safety Office. All radiation producing machines must be checked annually to assure compliance with Title 17 of the California Code of Regulations.

7.5 Warning Signs and Signals

All devices and equipment capable of producing radiation when operated shall be appropriately labeled so as to caution individuals that use such devices or equipment. Each area in which Ionizing radiation exists shall be posted in accordance with Title 17 of the California Code of Regulations. An “X-Ray Safety Guidelines” shall be posted in each room containing radiation producing machines.

7.6 Operation Signals

Each radiation machine which is capable of producing in any area accessible to individuals, a dose rate in excess of 100 milli-rems per hour shall be provided with a conspicuous visible or audible alarm signal such that any individual at or approaching the tube head or radiation port are made aware that the machine is producing radiation. This alarm signal shall be activated automatically only when radiation is produced and is not required for radiographic and fluoroscopic machines used solely in the healing arts.

7.7 Changes in Location and Disposition

Changes in the location or disposition of radiation producing machines must have prior approval of the RSO.

Environmental Health & Safety shall be given notice of intent to dispose of aradiation producing machine or transfer to another Sub-Licensee.

7.8 State Department of Health Services Notification

The RSO is responsible for notifying the State Department of Health Services, Radiological Health Section of the total number of machines including their type, location, use, and shielding. All radiation producing machines shall be registered.

7.9 Training

A. All persons authorized to use a radiation producing machine shall be trained in the safe use of x-ray machines. Exceptions to this training requirement shall be given to certified x-ray technologists.

B. Persons operating x-ray machines for the purpose of examination of human beings must be certified by the State of California in Diagnostic Radiologic Technology.

C. The State of California, Bureau of Radiological Health (California Code, of Regulations, Title 17-30462) requires Licentiates of the healing arts, including residents, fellows, and faculty physicians to obtain a certificate from the State for any one of the following activities:

1) Activation of an x-ray generator (machine).
2) Uses of fluoroscope.
3) Performs functions of a radiologist.
4) Supervises one or more certified radiologic technologists, or students of radiologic technology.

Exemptions: A physician shall not be required to obtain a certificate from the State if that physician:

1) Requests an x-ray examination through a certified supervisor and operator.

2) Performs radiology only in the course of employment by an agency of the Federal government and only at a Federal facility.

3) Has resided in California less than one year and is not yet Licensed in the healing arts by the State of California and operates x-ray producing equipment only under direct supervision of a certified supervisor and operator.

4) Applicants who are certified by the American Board of Radiology (ABR) are exempt from taking the exam, but must still apply for a certificate.

7.10 Sources of Incidental X-Rays

Some electrical equipment operating at potentials of 20 kV and above are capable of producing x-rays. Generally, only equipment operating at potentials of 30 kV and above are capable of producing x-rays of biological significance. Anyone acquiring or constructing equipment operating at 30kV and higher and employing cathode-ray tubes, rectifier tubes, klystrons, or magnetrons should contact the RSO so that the machine may be checked under operating conditions to insure that no significant exposures may occur to operating personnel.

7.11 Radiation Safety Requirements for Analytical X-Ray Equipment

A. Purpose and Scope. This part provides special requirements for analytical x-ray equipment. The requirements of this part are in addition to, and not in substitution for applicable requirements in other parts of these procedures.

B. Definitions.

(1) "*Analytical x-ray equipment*" means equipment used for x- ray diffraction or fluorescence analysis.

(2) "*Analytical x-ray system*" means a group of local and remote components utilizing x-rays to determine the elemental composition or to examine the microstructure of materials. Local components include those that are struck by x-rays such as radiation source housings port and shutter assemblies, Collimators, sample holders, cameras, goniometers, detectors and shielding. Remote components include power supplies, transformers, amplifiers, readout devices, and control panels.

(3) "*Fail-safe characteristics*" means a design feature which causes beam port shutters to close, or otherwise prevents emergence of the primary beam, upon the failure of a safety or warning device.

(4) "*Normal operating procedures*" means operating procedures for conditions suitable for analytical purposes with shielding and barriers in place. These do not include maintenance but do include routine alignment procedures. Routine and emergency radiation safety considerations are part of these procedures.

(5) *"Open-beam configuration*" means an analytical x-ray system in which an individual could accidentally place some part of his body in the primary beam path during normal operation.

(6) "*Primary beam*" means ionizing radiation which passes through an aperture of the source housing by a direct path from the x-ray tube or a radioactive source located in the radiation source housing.

C. Equipment Requirements

(1) **Safety Device**. A device which prevents the entry of any portion of an individuals body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A Sub-licensee may apply to the Radiation Safety Committee for an exemption from the requirement of a safety device. Such application shall include:

a) A description of the various safety devices that have been Evaluated;
b) The reason each of these devices cannot be used;

c) A description of the alternative methods that will be employed to minimize the Possibility of an accidental exposures including procedures to assure that operators and others in the area will be informed of the absence of safety devices.

(2) **Warning Devices**. Open-beam configurations shall be provided with a readily discernible indication of:

a) X-ray tube status (ON-OFF) located near the radiation source housing, if the primary beam is controlled in this manner; and/or
b) Shutter status (OPEN-CLOSED) located near each port on the radiation source housing, if the primary beam is controlled in this manner.

Warning devices shall be labeled so that their purpose is easily identified.

(3) **Ports**. Unused ports on radiation source housings shall be secured in the closed position in a manner which will prevent casual opening.

(4) **Labeling**. All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

a) "CAUTION - HIGH INTENSITY X-RAY BEAM, or words having a similar intent, on the x-ray source housing; and

b) "CAUTION - RADIATION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED, or words having a similar intent, near any switch that energizes an x-ray tube if the radiation source is an x-ray tube; or

c) "CAUTION - RADIOACTIVE MATERIAL," or words having a similar intent, on the source housing if the radiation source is a radionuclide.

(5) **Shutters**. On open-beam configurations each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

(6) **Warning** Lights. An easily visible warning light labeled with the words "X-RAY ON," or words having a similar intent, shall be located:

a) Near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized; or
b) In the case of a radioactive source, near any switch that opens a housing shutter, and shall be illuminated only when the shutter is open.

(7) **Radiation Source Housing**. Each x-ray tube housing shall be so constructed that with all shutters closed the leakage radiation measured at a distance of 5 cm from its surface is not capable of producing a dose in excess of 2.5 mrem in one hour at any specified tube rating. (Note: If radioactive sources are used, corresponding dose limits shall not exceed 2 mR per hour).

(8) **Generator Cabinet**. Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of 5 cm from its surface such that it is not capable of producing 0.25 mrem in one hour.

D. Area Requirements

(1) **Radiation Levels**. The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in Section 5 these procedures. For systems utilizing x-ray tubes, these levels shall be met at any specified tube rating.

(2) **Surveys**. Radiation surveys, as required of all analytical x-ray systems sufficient to show compliance with paragraph D(1) shall be performed by the sub-licensee:

a) Upon installation of the equipment;
b) Following any change in the initial arrangement, number, or type of local components in the system;
c) Following any maintenance requiring the disassembly or removal of a local component in the system;
d) During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed; and
e) Any time a visual inspection of the local components in the system reveals an abnormal condition.
f) Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the Radiation Goals (Section 5 of these procedures).
g) Radiation survey measurements shall not be required if a sub-licensee can demonstrate compliance to the satisfaction of the Radiation Safety Committee with D(1) in some other manner.

(3) **Posting**. Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol

and the words CAUTION - X-RAY EQUIPMENT, or words having a similar intent.

E. Operating Requirements

(1) *Procedures*. Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No person shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such person has obtained written approval of the RSO.

(2) *Bypassing*. No person shall bypass a safety device unless such person has obtained the written approval of the RSO. When a safety device has been bypassed, a readily discernible sign bearing the words “SAFETY DEVICE NOT WORKING,” or words having a similar intents shall be placed on the radiation source housing.

F. Personnel Requirements

(1) *Instruction*. No person shall be permitted to operate or maintain analytical x-ray equipment unless such person has received instruction in and demonstrated competence as to:

a) Identification of radiation hazards associated with the use of the equipment;
b) Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such
c) Proper operating procedures for the equipment;
d) Symptoms of an acute localized exposure, and
e) Proper procedures for reporting an actual or suspected exposure.

(2) *Personnel Monitoring*. Finger or wrist devices shall be provided to and shall be used by:

a) Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and

b) Personnel maintaining analytical x-ray equipment if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

G. Equipment Evaluation

(1) Each user shall maintain current utilization logs which shall be kept available for inspection, containing the following information for each radiation machine[8]:

(a) The identity of the machine.
(b) The location, date, and the identity of the individual operator for each use.
(c) The voltages current, and exposure time for each use

(2) Each user shall maintain and keep current written operating procedures for the kinds of radiation machines and kinds of radiographic procedures employed. Such procedures shall include detailed instructions in at least the following[9]:

(a) Means to be employed to control and limit exposure to individuals.
(b) Methods and occasions for conducting radiation surveys and for controlling access to radiography areas.
(c) The use of radiation survey instruments and personnel monitoring devices.

(3) The boundaries of the controlled area for each set-up shall be determined by a physical radiation survey, and appropriate limitations shall be imposed for controlling access to that area[10]

(4) Each radiation machine which is capable of producing, in any area accessible to individuals, a dose rate in excess of 100 milli-rems per hour shall be provided with a conspicuous visible or audible alarm signal such that any individual at or approaching the tube head or radiation port is made aware that the machine is producing radiation. Such alarm signal shall be activated automatically only when radiation is being produced.

(5) The control panel shall include a device to give positive indication of the production of x-rays whenever the x-ray tube is energized[11]

(6)(a) Each radiographic exposure device shall be provided with a lock or outer locked container designed to prevent unauthorized or accidental exposure and shall be kept locked at all times except during authorized use or when under the direct supervision of a radiographer or radiographer's assistant. In addition, during radiographic operations a sealed source assembly shall be secured in the shielded position each time the source is returned to that position.

(b) Each storage container and source changer shall be provided with a lock and kept locked when containing a sealed source except when the container is under the direct surveillance of a radiographer or radiographer's assistant.

(c) Locked radiographic exposure devices, storage containers and source changers shall be physically secured to prevent tampering or unauthorized removal[12].

(7) No user shall possess sources of radiation in such a manner as to create in any uncontrolled area, from such sources, radiation levels which could cause any individual to receive a dose to the whole body in excess of 2 mrem per hour.

7.12 Radiation Safety Requirements for Medical and Dental X-Ray Equipment

1. General Provisions

This Section pertains to use of x-rays in Medicine and Dentistry at California Polytechnic State University.

A. Equipment

1) No person shall make, sell, lease, transfer, lend or install x-ray equipment or the supplies used in connection with such equipment unless such supplies and equipment, when properly placed in operation or properly used, will meet the requirements of Title 17, California Code of Regulations and this Radiation Safety Manual.

B. Use

1) The Sub-Licensee shall ensure that all x-ray equipment under his/her Sub-License is operated only by persons adequately instructed and licensed by the State of California Department of Health Services.

2) The Sub-Licensee shall provide safety rules to each individual operating x-ray equipment under his/her control, including any restrictions of the operating techniques required for the safe operation of the particular x-ray apparatus.

3) No Sub-Licensee shall operate or permit the operation of x-ray equipment unless the equipment and installation meet the applicable requirements of CCR 17 and are appropriate for the procedures to be performed.

4) Deliberate exposure of an individual to the useful beam for training or demonstration purposes shall not be permitted.

5) Restraint of patients during examinations. No individual shall be regularly employed to hold or support humans during radiation

exposures. Operating personnel shall not perform this service except very infrequently and then only in cases where no other method is available. Any individual holding or supporting a person or animal during radiation exposures should wear protective gloves and apron having a lead equivalent of not less than 0.25 millimeter.

C. Shielding

1) Each installation shall be provided with such primary barriers and/or secondary barriers as are necessary to insure compliance with Sections 30265 and 30268 of the CCR Title 17. This requirement shall be deemed to be met if the thickness of such barriers are equivalent to those computed in accordance with Appendix C of the National Council on Radiation Protection and Measurements Report No. 34, Medical X-ray ant Gamma-Ray Protection for Energies up to 10 MeV (for medical installations and Appendix B of Report No. 35, Dental X-ray Protection (for dental installations).

2) Lead barriers shall be mounted in such a manner that they will not sag or cold-flow because of their own weight. They shall be protected against mechanical damage.

3) Joints between different kinds of protective materials shall be so designed that the overall protection of the barrier is not impaired.

4) Joints at the floor and ceiling shall be so designed that the overall protection is not impaired.

5) Windows, window frames, doors, and door frames shall have the same lead equivalent as that required of the adjacent wall.

6) Holes in protective barriers shall be covered so that overall attenuation is not impaired.

D. Definitions

1) *Automatic exposure control* - means a device which automatically controls one or more technique factors in order to obtain at a pre-selected location(s) a required quantity of radiation.

2) *Dead-man switch* - means a switch so constructed that a circuit-closing contact can only be maintained by continuous pressure by the operator.

3) *Diagnostic-type tube housing* - means an X-ray tube housing so constructed that the leakage radiation at a distance of 1 meter from the target cannot exceed 100 milli-roentgens in 1 hour when the tube is operated at any of its specified ratings.

4) *Filter* - means material placed in the useful beam to absorb preferentially the less penetrating radiations.

5) *Interlock* - means a device for precluding access to an area of radiation hazard either by preventing entry or by automatically removing the hazard.

6) *Leakage radiation* - means all radiation coming from within the tube housing except the useful beam.

7) *Protective barrier* - means a barrier of attenuating materials used to reduce radiation exposure.

8) *Primary protective barrier* - means a barrier sufficient to attenuate the useful beam to the required degree.

9) *Scattered radiation* - means radiation that, during passage through matter, has been deviated in direction.

10) *Secondary protective barrier* - means a barrier sufficient to attenuate stray radiation to the required degree.

11) *Shutter* - means a device, generally of lead, fixed to an X-ray tube housing to intercept the useful beam.

12) *Stray radiation* - means radiation not serving any useful purpose. It includes leakage and scattered radiation.

13) *Useful beam* - means that part of the radiation which passes through the window, aperture, cone, or other collimating device of the tube housing.

2. Medical Radiographic Installations

A. Equipment (Other than Dental and Veterinary Medicine Equipment)

1) The tube housing shall be of diagnostic type.

2) Suitable devices (diaphragms, adjustable collimators), capable of restricting the useful beam to the area of clinical interest shall be provided to define the beam and shall provide the same degree of

attenuation as that required of the tube housing. Such devices shall be calibrated in terms of the size of the projected useful beam at specified source-film distances. For chest photofluorographic equipment, the collimator shall restrict the beam to dimensions no greater than those of the fluorographic screen. The field size indication on adjustable collimators shall be accurate to within 2 percent of the source-film distance. The light field shall be aligned with the X-ray field with the same degree of accuracy.

3) For equipment manufactured prior to August 1, 1974, the aluminum equivalent of the total filtration in the useful beam shall be not less than that shown in table 7.1:

Table 7.1
Required Aluminum Equivalent Filtration
Pre-8/1/74 Equipment

Operating kVp	Minimum Total Filter (Inherent plus added)
Below 50 kVp	0.5 mm aluminum
50 - 70 kVp	1.5 mm aluminum
Above 70 kVp	2.5 mm aluminum

For equipment manufactured on or after 8/1/74, the half-value layer (HVL) of the useful beam for a given X-ray tube potential shall not be less than the appropriate value specified in Table 7.2:

Table 7.2
HVL of Useful Beam Based on X-ray Tube Potential
Post 8/1/74 Equipment

X-ray Tube Potential (kVp)	Measured Minimum HVL	Minimum HVL (mm Al)
Below 50	30	0.3
	40	0.4
	49	0.5
50 to 70	50	1.2
	60	1.3
	70	1.5
Above 70	70	2.1
	80	2.3
	90	2.5
	100	2.7
	110	3.0
	120	3.2
	130	3.5
	140	3.8
	150	4.1

4) A device shall be provided to terminate the exposure after a pre-set time or exposure.

5) A dead-man type of exposure switch shall be provided and so arranged that it cannot be conveniently operated outside a shielded area, except that exposure switches for “spot film” devices used in conjunction with fluoroscopic tables are excepted from this shielding requirement.

6) The control panel shall include a device (usually a milli-amp meter) to give positive indication of the production of X-rays whenever the X-ray tube is energized.

7) The control panel shall include devices (labeled control settings and/or meters) indicating the physical factors (such as kVp, mA, exposure time, or whether timing is automatic) used for the exposure.

8) Machines equipped with beryllium window X-ray tubes shall contain keyed filter interlock switches in the tube housing and suitable indication on the control panel of the added filter in the useful beam if the total filtration permanently in the useful beam is less than 0.55 mm aluminum equivalent. The total filtration permanently in the useful beam shall be clearly indicated on the tube housing.

9) The aluminum equivalent of table top when a cassette tray is used under the table top, or the aluminum equivalent of the front panel of the vertical cassette holder, shall not be more than 1 mm at 100 kVp.

B. Structural Shielding

1) All wall, floor and ceiling areas exposed to the useful beam shall have primary barriers. Primary barriers in walls shall extend to a minimum height of 80 inches above the floor.

2) Secondary barriers shall be provided in all wall, floor, and ceiling areas not having primary barriers or where the primary barrier requirements are lower than the secondary barrier requirements.

3) The operators station at the control shall be behind a protective barrier, either in a separate room, in a protected booth, or behind a shield which will intercept the useful beam and any. radiation which has been scattered only once.

4) A window with radiation attenuation equal to that required by the adjacent barrier, or a mirror system, shall be provided large enough and so placed that the operator can see that patient without having to leave the protective area during exposure. Provision shall be made for the operator to communicate with the patient from a shielded position at the control panel. When a door is required to shield the operator, electrical interlocks shall be provided to insure that exposures cannot be made when the door is open.

C. Operating Procedures

1) No individual occupationally exposed to radiation shall be permitted to hold patients during exposures except during emergencies, nor shall any individual be regularly used for this service. If the patient must be held by an individual, that individual shall be protected with appropriate shielding devices such as protective gloves and apron and he shall be so positioned that no part of his body will be struck by the useful beam.

2) Only individuals required for the radiographic procedure shall be in the radiographic room during exposure; and, except for the patient, all such persons shall be equipped with appropriate protective devices.

3) The radiographic field shall be restricted to the area of clinical interest.

4) Gonadal shielding of not less than 0.5 mm lead equivalent shall be used for patients who have not passed the reproductive age during

radiographic procedures in which the gonads are in direct beam, except for cases in which this would interfere with the diagnostic procedure.

5) The operator shall stand behind the barrier provided for his protection during radiographic exposures.

3. Dental Radiographic Installations

A. Equipment

1) The tube housing shall be of diagnostic type.

2) Diaphragms or cones shall be used for collimating the useful beam and shall provide the same degree of protection as the housing.

a) For intra-oral radiography the useful beam shall be restricted to a diameter of not more than 7 cm -(2.75 inches) at the surface of the skin.

3) For intra-oral film exposures a cone or spacer frame shall provide a target-to-skin distance of not less than 18 cm (7 inches) with apparatus operating above 50 kVp or 10 cm (4 inches) with apparatus operating at 50 kVp or below.

4) The total filtration permanently in the useful beam shall be equivalent to at least 0.5 millimeters of aluminum for equipment operating below 50 kVp, equivalent to at least 1.5 millimeters of aluminum for equipment operating from 50 kVp through 70 kVp, and equivalent to at least 2.5 millimeters of aluminum for equipment operating above 70 kVp.

5) A device shall be provided to terminate the exposure after a pre-set time or exposure.

6) The exposure control switch shall be of the dead-man type. If a recycling timer is employed it shall not be possible to make a repeat exposure without release of the exposure switch to reset the timer.

7) Each installation shall be provided with a protective barrier for the operator or shall be so arranged that the operator can stand at least 6 feet from the patient and well away from the useful beam.

8) Mechanical support of the tube head and cone shall maintain the exposure position without a drift or vibration.

9) Panoramic installations. This part applies to those installations which consist of a tube head with a collimator providing a narrow useful beam and an extra oral film carrier with which are interlocked in their motion about the patient.

   a) All provisions of Section 3(A) apply except 3(A)(2)(a), 3(A)(3), and 3(A)(10).

10) The X-ray control panel shall include means for indicating X-ray tube voltage (kVp), tube current (mA), and exposure duration. The tube voltage and current shall be indicated by meters or by control settings. A milli-ammeter, a light or other device shall give clear and distinct visual or audible indication to the Operator when X-rays are being produced.

B. Structural Shielding

1) Dental rooms containing X-ray machines shall be provided with primary barriers at all areas struck by the useful beam.

2) When dental X-ray units are installed in adjacent rooms or areas, protective barriers shall be provided between the rooms or areas.

C. Operating Procedures

1) No individual occupationally exposed to radiation shall be permitted to hold patients or films during exposure, nor shall any individual be regularly used for this service.

2) During each exposure, the operator shall stand at least 6 feet from the patient or behind a protective barrier.

3) Only the patient shall be in the useful beam.

4) Neither the tube housing nor the pointer cone shall be hand-held during exposure.

5) Fluoroscopy shall not be used in dental examinations.

6) Each patient undergoing dental radiography shall be draped with a protective apron of not less than 0.25 millimeter lead-equivalent to cover the gonadal area.

7) For intra-oral and cephalometric radiography the X-ray beam and the film shall be aligned very carefully with the area to be radiographed.

8) Only persons required for the radiographic procedure shall be in the radiographic room during exposures.

7.13 Radiation Safety Requirements for Veterinary X-Ray Equipment

A. Equipment

1) The tube housing shall be of diagnostic type.

2) Diaphragms or cones shall be provided the same degree of protection to the area of clinical interest and shall provide the same degree of protection as is required of the housing.

3) The total filtration permanently in the useful beam shall not be less than 1.5 millimeters aluminum-equivalent for equipment operating up to 70 kVp and 2.0 millimeters aluminum-equivalent for machines operated in excess of 70 kVp.

4) A device shall be provided to terminate the exposure after a pre-set time or exposure.

5) A dead-man type of exposure switch shall be provided, together with an electrical cord of sufficient length so that the operator can stand out of the useful beam and at least 6 feet from the animal during all X-ray exposures.

B. Structural Shielding

1) All wall, ceiling, and floor areas shall be provided with applicable protective barriers to ensure that exposures are minimized and that no applicable dose limits are exceeded.

C. Operating Procedures

1) The operator shall stand well away from the tube housing and the animal during radiographic exposures. The operator shall not stand in the useful beam. If film must be held, it shall be held by individuals not occupationally exposed to radiation. Hand-held fluoroscopic screens shall not be used. The tube housing shall not be held by the operator. No individuals other than the operator shall be in the x-ray room while exposures are being made unless such person's assistance is required.

2) In any application in which the operator is not located behind a protective barrier, clothing consisting of a protective apron having a

lead-equivalent of not less than 0.25 millimeter shall be worn by the operator and any other individuals in the room during exposures.

3) No individual shall be regularly employed to hold or support animals during radiation exposures. Operating personnel shall not perform this service except very infrequently and then only in cases in which no other method is available. Any individual holding or supporting an animal during radiation exposure shall wear protective gloves and apron having a lead-equivalent of not less than 0.25 millimeter.

7.14 Radiation Safety Requirements for Industrial Radiography

A. Radiography Employing Radiation Machines

Definitions, for purposes of this section, and special requirements for various categories of radiography employing radiation machines are as follows:

(1) Cabinet radiography is that which is conducted in an enclosed, interlocked cabinet, such that the radiation machine will not operate unless all openings are securely closed, and the interior which is so shielded that every location on the exterior meets conditions for an uncontrolled area as specified in CCR Title 17 Section 30268, 10 CFR 20.1301, or Section 5.1 of these procedures. Cabinet radiography shall be subject to the following special conditions:

(a) No user shall permit any individual to operate a cabinet radiography unit until such individual has received a copy of and instruction in, and demonstrated an understanding of, operating procedures for the unit, and has demonstrated competence in its use.

(2) Shielded room radiography is that which is conducted in an enclosed room, the interior of which is not occupied during radiographic operations, which is so shielded that every location on the exterior meets conditions for an uncontrolled area as specified in CCR Title 17 Section 30268, 10 CFR 20.1301 or Section 5.1 of these procedures, and the only access to which Is through openings which are interlocked so that the radiation machine will not operate unless all openings are securely closed. Shielded room radiography shall be subject to the following special conditions:

(a) No user shall permit any individual to operate a shielded room radiography unit until such individual has received a copy of instructions in and demonstrated an understanding of operating

procedures for the unit, and has demonstrated competence in its use.

(b) Each user shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by, every individual who operates, who makes “set-ups”, or who performs maintenance on a shielded room radiography unit.

B. Permissible Levels of Radiation in Uncontrolled Areas

1) No user shall possess sources of radiation in such a manner as to create in any uncontrolled area, from such sources, radiation levels which could cause any individual to receive a dose to the whole body in excess of:

(a) two milli-rems in any one hour; or
(b) 0.1 rem (100 mrem) in any one year

C. Special Requirements for High Radiation Areas and Radiation Machines Capable of Producing High Radiation Areas

1) The following special requirements are applicable for high radiation areas:

(a) Except for high radiation areas caused by radiographic and fluoroscopic machines used solely in the healing arts, each entrance or access point to a high radiation area shall be:

1) equipped with a control device which shall cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 milli-rems in 1 hour upon entry into the area; or

2) equipped with a control device which shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering the high radiation area and the licensee or a supervisor of the activity are made aware of the entry; or

(3) maintained locked except during periods when access to the area is required, with positive control over each individual entry.

D. Radiography Employing Radiation Machines

1) During each radiographic operation, the operator shall maintain direct surveillance of the operation to protect against unauthorized entry into a high radiation area unless entry into such area is positively controlled by other suitable means.

2) Each user shall maintain current utilization logs which shall be kept available for inspection at the address specified on the registration form, containing the following information for each radiation machine:

   (a) The identity of the machine.
   (b) The location, date, and the identity of the individual operator for each use.
   (c) The voltages current, and exposure time for each use.

7.15 Radiation Safety Requirements for Cabinet Radiography

A. Equipment Evaluation

1. Each user shall maintain current utilization logs which shall be kept available for inspection, containing the following information for each radiation machine[13]:

   (a) The identity of the machine.
   (b) The location, date and the identity of the individual operator for each use.
   (c) The voltage, current, and exposure time for each use.

2. No user shall possess sources of radiation in such a manner as to create in any uncontrolled area, from such sources, radiation levels which could cause any individual to receive a dose to the whole body in excess of 2 mrem per hour or 100 milli-rem in a year.

3. Each radiation machine which is capable of producing, in any area accessible to individuals, a dose in excess of 100 milli-rem per hour shall be provided with conspicuous visible or audible alarm signal such that any individual at or approaching the tube head or radiation port is made aware that the machine is producing radiation. Such alarm signal shall be activated automatically only when radiation is being produced.

4. The control panel shall include a device to give positive indication of the production of X-rays whenever the X-ray tube is energized.

8. TRAINING

Title 17, California Code of Regulations, Section 30280, requires that a Licensee instruct his personnel regarding health and safety rules and problems applicable to the use of sources of radiation

8.1 Formal Training of New Sub-Licensees

Will be conducted by the RSO. The training should include instruction in:

A) California Polytechnic State University Radiation Safety Manual and Forms.
B) Current applicable laws and regulations.
C) Standards set by regulations and license conditions.
D) Operating and emergency procedures.

8.2 Format training of New Student Personnel under direct supervision of the Sub-Licensee.

Training and instruction of new personnel is the responsibility of the Sub-Licensee. This training should include instruction in:

A) The nature of radiation and its interaction with matter.

B) Definitions of units of dose, quantity, etc., and methods of calculating and measuring radiation levels for an appropriate variety of sources.

C) The biological effects of chronic and acute doses of various radiations.

D) Methods of control and measurement of surface contamination.

E) Personnel dosimetry and bioassay procedures.

F) The proper use of protective clothing and equipment.

G) Standards set by regulations and license conditions.

H) Operating and emergency procedures specific to the individual Sub-License.

I) Proper maintenance of records of receipt, use, transfer and disposal.

8.3 Periodic Retraining of Student Personnel.

This should by presented by Sub-Licensees and would include instruction in:

A) Changes in regulations, State license conditions, Sub-License conditions and their consequences to the Sub-Licensee's operations.

B) Changes in operating procedures.

C) Emergency procedures and problems.

8.4 CPSU Employees

The campus Injury and Illness Prevention Program (IIPP) assigns responsibility for safety training of campus faculty and staff to department chairs / heads and Deans. Janitorial personnel are provided training by the Sub-Licensee or the RSO and are instructed on cleaning procedures for Sub-Licensed facilities, and any related radiation safety procedures.

8.5 Training of Campus Public Safety Personnel

Will be conducted by the RSO. The training should include instruction in:

A) California Polytechnic State University Radiation Safety Manual and Forms.

B) Current applicable laws and regulations.

C) Standards set by regulations and license conditions.

D) Operating and emergency procedures.

8.6 Radiation Work Permit

Upon notification to Environmental Health and Safety Office of work to be performed, a Radiation Work Permit (Form 9) will be posted in the rooms to provide radiation safety requirements for those individuals who will be performing work in the sub-licensed facilities. Prior radiation safety training may be required before access to certain facilities.

9. RADIATION ACCIDENT PROCEDURE

9.1 Area Contamination

A) Major contamination involving potential health hazard.

In the event of spread or suspected spread of radioactive contamination over a room or portion of a room:

1) Vacate the area, leaving behind clothing and other articles which may have been contaminated;

2) Have the ventilation system turned off;

3) Notify the RSO immediately - weekdays, 0800-1700, extension 66662; other times, or if the RSO is not immediately available, call the University Police , extension 62281, who will contact the RSO or other appropriate personnel;

4) Keep all persons out of the area except as directed by the RSO or designated individual;

5) Monitor to evaluate (residual) personnel contamination;

6) Carry out appropriate decontamination procedures under the direction of RSO;

7) If necessary, in accordance with 17 CCR Sections 30295 & 30297, notification and report to the state Department of Health Services will be carried out by the RSO.

B) Minor contamination involving no immediate health hazard should be dealt with promptly but carefully. Notify the Radiation Safety Officer if there are residual areas of work surfaces, floors, walls or equipment which have not been successfully cleaned .

9.2 Personal Contamination.

A) Skin Contamination:

1) 1) Thorough washing with a mild soap or detergent in tepid water for about 2 minutes with a good lather is probably the best general method off decontaminating the hands and other parts of the body. Give special attention to the areas between the fingers and around the fingernails.

2) 2) DO NOT use highly alkaline or abrasive soap. Repeat as necessary if monitoring indicates that the degree of decontamination is insufficient, but DO NOT exceed three or four washes.

1) 3) If the above procedure is insufficient to remove the contamination, notify the Radiation Safety Officer.

B) Contaminated wounds and ingestion of radioactive material.

1) 1) Persons cut by glassware or injured by contaminated instruments should wash the injured part under a strong steady stream of water as soon as possible following the injury. Do not delay in arranging prompt medical attention and/or reporting the injury to the Radiation Safety Officer.

2) Persons swallowing radioactive materials should be handled as in acute chemical poisoning cases. Prompt medical attention should be arranged.

C) Incident Report (Form 12) and Surface Contamination Monitoring Record (Form 13) must be filled out and submitted to the Radiation Safety Officer within 24 hours.

9.3 Overexposure

In the event of an overexposure or excessive levels of radiation delivered to the whole body, skin or extremities:

A) Notify the RSO weekdays, 0800-1700, extension 66662; other times call the University Police, extension 62281, who will contact the RSO.

B) If necessary, in accordance with CCR Title 17, 30295 and 30297, notification and reporting to the State Department Health Services, Radiological Health Section, will be carried out by the RSO.

C) Do not delay in arranging prompt medical attention should an exposure in excess of the limits in table 5.1 be suspected or if skin erythema or any other non-stochastic injury should appear.

D) Incident Report (Form 12) must be filled out and submitted to the RSO within 24 hours.

9.4 Emergency Pre-plans

Fire hazard classification (FHC) is used for emergency pre-plans to identify hazards encountered associated with the use of radioactive materials in laboratories and rooms.

A) The formula used to calculate the hazard values is as follows:

F = **THINK**, where:

F = fire hazard value-
T = quantity of radionuclide (in uCi),
H = possible injury due to toxicity,
I = identification of how material is used,
N = susceptibility of materials to burning,
K = explosive decomposition or reaction releasing energy.

Using the Identification of Health Hazard Guide, Table 9.3, **H**, **N**, and **K** values are assigned from 0.1 to 4.

The values for **I** is taken from table 9.1:

Table 9.1
Values for "I"

Type of Operation	Use Factor
Sealed Sources	0.001
Storage	0.01
Simple wet operations	0.1
Simple dry operations	1
Complex wet operation	10
Complex dry operations	100

When mixed uses are present, average the use factors to obtain the value for I.

The Fire Hazard Classification is a function of the Fire Hazard Value as shown in table 9.2:

Table 9.2
Fire Hazard Values

Fire Hazard Value (F)	Fire Hazard Classification
0 to 10	Fire Class A
11 to 1000	Fire Class B
1001 to 270000	Fire Class C
over 270000	Fire Class D

Class A

Laboratory operations are performed on adsorbent pads placed on working surface. ABC fire extinguishers; Normal fire fighting techniques are used.

Class B

Minimum requirement that operations be carried out in fume-hoods. ABC fire extinguishers; Normal fire fighting techniques are used; Respirators worn at all times while in the room.

Class C

Minimum requirement that operations be carried out in glove boxes and atmospheric controls be incorporated for total laboratory. ABC fire extinguishers; Possible halon system, Normal fire fighting techniques are used; Respirators worn at all times while in room. “C” stands for CALL the RSO and/ or the Sub-Licensee.

Class D

Restricted laboratory or room must have radiation monitoring personnel present for entry. “D” stands for DON’T enter room or laboratory, and CALL the RSO and/ or the Sub-Licensee.

Table 9.3 here

Endnotes
Clarification, references, and statements of consideration

[1] There is a recognized relationship between DAC hours and ALI. 2000 DAC hours is assumed to be equivalent to an ALI, and equal to either 5 rem or 50 rem, depending on the basis for the DAC and ALI. Typically, there is an assumption of a 40 hour work week. Using 12 DAC hours in a week as a definition for considering an area an Airborne Radioactivity Area, assuming constant concentrations, and assuming a 40 hour nominal work week means that posting may be required at 0.3 DAC. From a practical standpoint, if an airborne condition exists for a short period of time, posting and protection considerations can be applied using time-weighting as is common with other industrial hygiene related situations.

[2] Shleien, B., et al, "*Handbook of Health Physics and Radiological Health, Third Edition*", Baltimore: Williams & Wilkins, 1998.

[3] 10CFR20, Table 1004(b).2.

[4] The declaration of pregnancy by a female employee to the radiation safety officer is an individual choice of the employee

[5] Care must be taken when assigning dose based on DAC-hours. Some radionuclides have a stochastic, or probabilistic harm basis. That means that the calculated end point is deemed more probable with higher dose but severity dose not rise with higher doses. Others are non-stochastic harm basis. This means that insult to the organ or tissue is limiting organs and tissues are weighted to make this harm equivalent to some magnitude of external exposure. Therefore, some DAC values equate to a limiting organ dose of 50 rem CDE, some relate to a committed effective dose equivalent of 5 rem CEDE. It is possible to use the stochastic DAC, calculate a CEDE value below 5 rem and still exceed the 50 rem organ limit. See Iodine 131 as an example.

[6] American Nation Standard ANSI/HPS N13.14-1994, Internal Dosimetry Programs for Tritium Exposure - Minimum Requirements.

[7] International Commission on Radiological Protection, *Report of the Task Group on Reference Man*, ICRP Report 23, Pergamon Press, 1975.

[8] 17 CCR 30336[c](7)

[9] 17 CCR 30336[c](2)

[10] 17 CCR 30336[c](4)

[11] 17 CCR 30308[a](6)

[12] 17 CCR 30332.1

[13] 17 CCR 30336[c](7)