

IONIZING RADIATION SAFETY MANUAL



CALIFORNIA STATE UNIVERSITY, FRESNO
ENVIRONMENTAL HEALTH, SAFETY, AND RISK MANAGEMENT
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Article I. Forward

The California Department of Public Health Radiologic Health Branch (RHB) under Title 17 Division 1 Chapter 5 of the California Code of Regulations has the responsibility to approve or disapprove each proposed use of Radioactive Materials (RAM) or Radiation Producing Devices subject to its specific licensure. For the administrative convenience of the Department and California State University, Fresno, the RHB has issued a Radioactive Material License to California State University, Fresno. This license delegates to California State University, Fresno the authority and responsibility for licensing individual uses of radioactive material (RAM). The license also contains certain special requirements that California State University, Fresno must satisfy.

This document is intended to serve as a reference to guide all radioisotope and ionizing radiation producing machine users on the California State University, Fresno campus and to ensure that all requirements and regulations of the RHB and Title 17 are met. RHB has adopted, specifically in Title 17 CCR Section 30253, the regulations contained in Title 10 Code of Federal Regulations Part 20 to govern the use of RAM for its licensees. The applicable code sections are cited in this manual. The rules, procedures, and limits presented here are intended to satisfactorily address radioisotope or radiation usage needs. For unusual experiments, users should consult the California State University, Fresno Radiation Safety Committee (RSC) and other documents more comprehensive than this manual.

Article II. Table of Contents

Article I. Forward.....	2
Article II. Table of Contents.....	3
Article III. Program Contacts	5
Article IV. Radiation Safety Committee Members	6
Article V. Ionizing Radiation Safety Organization and Program.....	7
Section 5.01 Organizational Chart.....	7
Section 5.02 Radiation Safety Committee.....	8
Section 5.03 Radiation Safety Officer.....	8
Section 5.04 Registered User	9
Article VI. Projects Under the Jurisdiction of the Radiation Safety Program	10
Section 6.01 University Affiliated Radiation Work.....	10
Section 6.02 Non-University Affiliated Radiation Work.....	10
Article VII. Use of Radioactive Materials and Equipment Producing Ionizing Radiation.....	11
Section 7.01 Project Approval Procedure	11
Section 7.02 Project Renewals and Cancellations.....	11
Section 7.03 Procurement of Radioactive Materials and/or Ionizing Radiation Equipment.....	11
Section 7.04 Transfer of Radioactive Materials within the University.....	12
Section 7.05 Shipment of Radioactive Materials	12
Section 7.06 Administration of Radioactive Materials to Animals	12
Section 7.07 Administration of Radioactive Materials to Humans	12
Section 7.08 Radioactive Wastes	12
Section 7.09 Storage of Radioactive Materials	13
Section 7.10 Personnel Safety	13
Article VIII. Dose Limitations	15
Section 8.01 ALARA	15
Section 8.02 Regulatory Limits	16
Article IX. Basic Radiation Safety Principles and Work Rules	18
Section 9.01 Control of External Exposure.....	18

Section 9.02	Control of Internal Exposure	19
Section 9.03	Work Practices.....	20
Article X.	Hazard Assessment.....	21
Section 10.01	Estimation of Exposure	21
Article XI.	Accidents, Overexposures, and Contamination	22
Section 11.01	Reporting.....	22
Section 11.02	Radiation Accidents.....	22
Section 11.03	Radioactive Contamination - Area	22
Section 11.04	Radioactive Contamination - Personnel.....	22
Article XII.	Radiation Monitoring.....	24
Section 12.01	Routine Surveys.....	24
Section 12.02	Special Monitoring	24
Section 12.03	Personal Monitoring.....	24
Section 12.04	Dosimetry	24
Section 12.05	Radiation Detection Equipment.....	24
Section 12.06	Decommissioning and Decontamination	25
Article XIII.	Current Radiation Detection Instruments Available to Conduct Surveys and Hazard Assessments.....	26
Section 13.01	Instrument list:	26
Article XIV.	Revision History	27

Article III. Program Contacts

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Radiological Health Branch (non-emergency)		California Department of Public Health	916.3275106

Article IV. Radiation Safety Committee Members

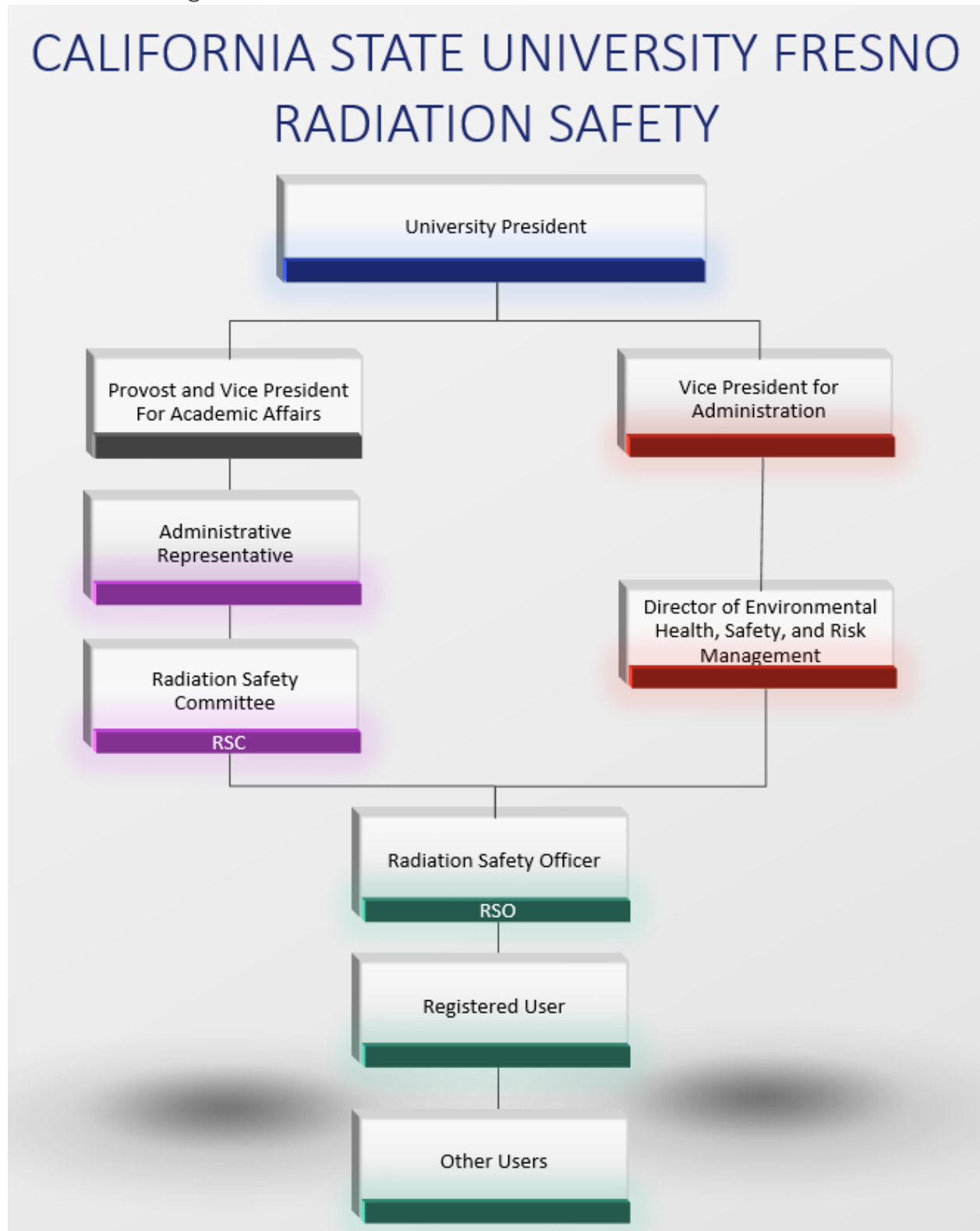
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Physical Therapy Representative ^{1,3}	Vacant	Physical Therapy	-	-

¹Counted towards quorum for committee meetings

²Required attendee for committee meetings

³At least one representative from each department is required at each meeting

Article V. Ionizing Radiation Safety Organization and Program
Section 5.01 Organizational Chart



Section 5.02 Radiation Safety Committee

- (a) The RSC will be composed of at least five members who will meet quarterly or more frequent basis to review applications for radioisotope and ionizing radiation use and to develop policies which assure the safe use of radioisotope and radiation equipment. A quorum shall consist of a majority of the membership of the RSC and must include the Radiation Safety Officer (RSO) or designated alternate. If there is no significant business to transact, quarterly meeting may be canceled by the Chairman of the RSC with the approval of a majority of the members.
- (b) The RSC will consist of the RSO, an administration representative, and representatives from each department with RAM or radiation producing machines in use or storage for a total membership of at least five. All members of the RSC, except for the administration member, must be a registered user.
- (c) The RSC derives its authority from the President of the University through the President's Administrative Representative. The academic RSC members are appointed by the Provost and the Vice President for Academic Affairs, who authorizes the RSC to make and enforce regulations pertaining to the use of RAM and ionizing radiation on the California State University, Fresno Campus. See the organizational chart above in section 5.01.
- (d) Responsibilities of the RSC and its members:
 - (i) Evaluate the submission(s) of annual review of the RSM conducted by the RSO and vote to approve or reject any revisions until an approved version of the RSM is generated for each year.
 - (ii) Participate in the new registered user approval process for all new applicants.
 - (iii) Participate in the new project approval process for all new project submissions including review of hazard assessments.
 - (iv) Annually elect a Chairperson and a Recording Secretary from among its members.

Section 5.03 Radiation Safety Officer

- (a) The RSO shall be appointed by the director of Environmental Health, Safety, and Risk Management (EHSRM) and approved by the RSC. The RSO shall report to both EHSRM and the RSC. The RSO must be a registered user and shall have extensive training in all phases of radioisotope and ionizing radiation work.
- (b) The authority of the RSO is derived from the RSC, and the provisions of the Radioactive Materials License and the Radiation Safety Manual (RSM).
- (c) The duties of the RSO include:
 - (i) Provide guidance to new users to complete new registered user process, new project applications and submission of forms to the RSC for consideration.
 - (ii) Provide assistance with the registration of radiation producing machines when required.
 - (iii) Conduct preliminary hazard assessments and provide the results of those hazard assessments to the RSC for consideration during the new project application process.
 - (iv) Advising the RSC regarding implementation of the program.
 - (v) Inspection of on-going projects.
 - (vi) Conducting laboratory surveying and monitoring.
 - (vii) Facilitate the proper disposal of radioactive wastes.

- (viii) Maintaining required records.
- (ix) The RSO shall provide registered users a copy of the RSM initially, and following RSC approved modifications of the RSM.
- (x) The RSO will annually review the RSM to ensure that it complies with current Title 17 and other relevant State and Federal regulations along with any changes related to program elements e.g., new detection instruments, administrative process changes, training requirement changes. Any revisions to the RSM must be approved by the RSC.

Section 5.04 Registered User

- (a) Registered users are required to meet the following minimum qualifications prior to being considered for registration:
 - (i) A college degree or the equivalent in the physical, biological, or health sciences; and
 - (ii) At least 40 hours of training or practical experience in the characteristics of ionizing radiation, and radiation dose quantities, radiation detection instrumentation, and the biological hazards of exposure to radiation appropriate to the types and forms of radiation sources to be used.⁴
- (b) Responsibilities of Registered Users or those wishing to become registered users are:
 - (i) To submit a new user registration form for consideration by the RSC.
 - (ii) To obtain required radiation detection equipment identified during the hazard assessment or project approval process and ensure that it is functional.
 - (iii) To ensure that calibration of required detection equipment identified during the hazard assessment or project approval process is completed for periods of time when potential sources of ionizing radiation are in the possession of the Registered User.
 - (iv) Radiation producing machines are required to be registered. All registration paperwork and fees associated with registration are the responsibility of the registered users, or their department.
- (c) Registered users application approval is obtained through RSC vote and simple majority in favor is all that is required for completion of registration process.

⁴ This requirement may be satisfied by completing the first five weeks of Physics 136.

Article VI. Projects Under the Jurisdiction of the Radiation Safety Program

Section 6.01 University Affiliated Radiation Work

- (a) All projects and personnel engaged therein which utilize any material or device capable of producing ionizing radiation come within the scope of the Radiation Safety program. Projects and personnel utilizing ionizing radiation under the following conditions are subject to this section.
- (b) Projects or personnel supported by University funds or as part of contracts administered by the University, wherever the work is conducted. In such cases, monitoring, issuing of personnel monitoring devices, and supervision of radiation safety regulations are the responsibility of the RSC. In some contract or off-campus projects, responsibility may be delegated to an agent, a user, approved by the RSO acting for the RSC.
- (c) The work is carried out on University owned or controlled property whether by University personnel or not.

Section 6.02 Non-University Affiliated Radiation Work

- (a) University personnel working with ionizing radiation on their own initiative and without direction from the University at another institution, where that institution supplies the radioactive material or radiation producing device and the working facilities, do not come within the scope of the University Radiation Safety program. It is considered that they are not acting as agents of the University, and that monitoring and other radiation safety measures are the responsibility of the other institution.

Article VII. Use of Radioactive Materials and Equipment Producing Ionizing Radiation

Section 7.01 Project Approval Procedure

- (a) A User Registration Form must be submitted to the RSO to be made available to the RSC review for each person wishing to have a project approved.
- (b) A Project Application Form, in conjunction with a clear description of the intended use of RAM or of devices producing ionizing radiation, must be submitted to the RSO for approval by the RSC for all new projects. A clear description may include a standard operating procedure, or a lab manual that accurately reflects the use of the RAM or instruments capable of producing ionizing radiation in question. The applicant may be required to meet with the RSC to obtain approval. Approvals will be for a period of no more than one year.
- (c) An Annual Project Review Form must be submitted to the RSO annually for approval of continuing projects by a date determined by the RSO but in no case later than October 15. If a project has been concluded the RSO must be notified in writing at the termination of the project.
- (d) Applications for RAM work in other than University facilities that does not meet the conditions set forth in section 6.01 must be accompanied by authorization for said work by the host institution.

Section 7.02 Project Renewals and Cancellations

- (a) Registered users wishing to conduct projects will continue for a period of time longer than one year shall
 - (i) Submit a project renewal request to the Radiation Safety Officer annually for approval of continuing projects by a date determined by the RSO but in no case later than October 15.
 - (ii) If a project has been concluded, a cancellation notice should be filed with the RSO at the termination of the project to ensure proper waste handling.

Section 7.03 Procurement of Radioactive Materials and/or Ionizing Radiation Equipment

- (a) The project application procedure described in article five above will be followed regardless of the source of the RAM and/or devices, i.e., whether obtained by purchase, loan, or gift. Purchase of RAM and/or of devices producing ionizing radiation will be through normal University purchasing channels. However, the "requisition form" submitted to the Purchasing Department must be approved and signed by the RSO. The user shall specify on the purchase requisition that the material to be ordered is RAM or that the device produces ionizing radiation. The RSO will approve all purchase requisitions for RAM and/or devices for projects which have been approved by the RSC. The RSO will add to the purchase requisition, the California State University, Fresno Radioactive Materials License Number if required for that purchase. This approval informs the University Purchasing Department that the authorization for radiation use has been obtained, and confirms that the individual is a "Registered User" of RAM and/or devices producing ionizing radiation.

(b) Purchase requisitions shall state that ordered material is to be delivered to the RSO. This will facilitate record-keeping and also allow the RSO to check for leakage prior to delivery to the registered user.

(c) Ionizing radiation producing machines may be required to be registered with RHB.

Section 7.04 Transfer of Radioactive Materials within the University

(a) Transfer of RAM from one department or project to another within the University must have prior approval of the RSC, unless the material is being transferred to the RSO for waste disposal purposes only.

(b) The Transfer of Radioactive Material form is required to be submitted to the RSO for approval by the RSC prior to transferring any materials. Unauthorized transfers may result in termination of approval for RAM work by the offending parties.

Section 7.05 Shipment of Radioactive Materials

(a) Shipment of RAM off-campus must conform to appropriate State and Federal transportation regulations.

(b) The RSO must be informed prior to any shipment of such materials from the University in order to ensure compliance with RHB requirements and Federal Department of Transportation Regulations.

Section 7.06 Administration of Radioactive Materials to Animals

(a) Animals given RAM should be caged separately from other animals.

(b) Cages shall be labeled with appropriate radiation warning signs. The nuclide, quantity and date of administration, as well as the name of the person responsible for the experiment, should be specified on the cage labels.

(c) If the excreta might be radioactive, arrangements must be made (in planning the experiment) for its collection in such a manner as to minimize contamination of cages and surrounding areas.

(d) If the nuclide form is such that significant quantities of radioactivity may be released during animal respiration, metabolic type cages fitted with suitable filters or scrubbers may be specified by the RSO.

(e) Handling and disposal of radioactive excreta and animal carcasses or tissues shall be as specified by the RSO.

(f) Registered users are responsible for assuring that non-registered users are escorted in areas where RAM is used or stored are aware of potential hazards and suitably trained in the necessary precautions to prevent harm.

(g) Administration of radioisotopes to animals which are not the property of the University is not authorized.

Section 7.07 Administration of Radioactive Materials to Humans

(a) At the present time, the University is not authorized to approve any project involving the administering of RAM to humans.

Section 7.08 Radioactive Wastes

- (a) In planning a project using RAM, consideration shall be given to the nature, quality, and degree of contamination to facilitate the proper disposal of radioactive wastes which may result. The RSO shall specify means of handling and treating such wastes. Liquid wastes and animal carcasses or tissues require special treatment.
- (b) In all cases, radioactive waste must be sealed container and placed in a secure location. In addition, the container must be labeled as to type and amount of isotope, chemical form of isotope, storage date and outside surface radiation level (if applicable) in millirems/hour. RAM wastes with a half-life of 120 days or less shall be separated from long half-life material. In all cases, the RSO is to be notified when disposal of radioactive waste is needed.
- (c) Registered users are required to maintain an up-to-date log of all radioisotopes under their control. The log shall specify the portion used and unused, if applicable, the amount of waste accumulated and shall account for losses e.g., by vaporization, respiration, decay, disposal, etc. The RSC may require more frequent inventory reporting at its discretion.

Section 7.09 Storage of Radioactive Materials

- (a) When not in use, RAM shall be stored in a secure area with sufficient radiation shielding to ensure compliance with Sections 4.12 and 4.14. Note that H-3 (18.6 keV) and C-14 (156 keV) are soft beta emitters and are adequately shielded by almost any container (0.005 mm and 0.24 mm of Lucite, respectively). P-32 (1.71 MeV) is a hard beta emitter and although the betas are easily stopped, (6.44 mm of Lucite), bremsstrahlung production can sometimes be a problem and should be controlled with a lead outer container and an inner container of a low Z material.
- (b) Under Title 10 CFR Section 20.1902 any area in which there is stored or used more than ten times the quantity specified in Appendix C to Title 10 CFR Sections 20.1001-2401 must be posted with a magenta and yellow CAUTION RADIOACTIVE MATERIAL sign carrying the familiar three-bladed symbol.

Section 7.10 Personnel Safety

- (a) All operations involving actual or potential exposure to ionizing radiation requiring approval shall be under the direct supervision of a registered user approved by the RSC.
- (b) Training
 - (i) California Code of Regulation Title 17 Section 30255 requires that a licensee instruct personnel regarding health and safety rules and the problems related to the use of sources of radiation.
 - (ii) Radiation safety training is required to be taken by any campus community member who, during the course of their assigned duties, enters into a controlled area where work requiring project approval occurs.
 - (iii) Radiation safety training is not required to be taken by students receiving instruction with radioactive materials who meet all of the following conditions:
 - 1) They are under the supervision of the registered user the entire time RAM is in use.
 - 2) A hazard assessment documented during the RAM approval process for the project in question indicates that the expected dose does not exceed regulatory limits outlined in Section 8.02 of this document.

- 3) The supervising registered user ensures any necessary safety training or preventative measures are implemented for the community member observing or receiving instruction to prevent exposure above the aforementioned dose limits.
- (iv) Students that do not meet all of the criteria mentioned in 5.09(d)(II) above are either:
- 1) Required to attend a radiation safety training approved by the RSO
or
 - 2) Demonstrate having received equivalent training elsewhere which could include instructional coursework if appropriate
- (c) Registered users are responsible for assuring that equipment and facilities available are adequate for protection of personnel and property. Chemical fume hoods used working with unsealed radioactivity, may require additional considerations/controls to prevent cross contamination. Fume hoods used for unsealed radioactivity must not share duct work with any other fume hoods. All equipment and facilities are subject to inspection by the RSO and approval for use by the RSC.
- (d) Unnecessary or unauthorized exposure and the careless or intentional omission of protective devices is prohibited. The RSC shall deny permission to engage in radiation work to any individual who does not exercise due and proper health and safety precautions.
- (e) Registered users are responsible for informing the RSC before personnel additions are made to a project or after personnel terminations on any project using radiation.

Article VIII. Dose Limitations

Section 8.01 ALARA⁵

- (a) Recommendations from the National Council on Radiation Protection and Measurements (NCRP) were initially published as a series of handbooks from the National Bureau of Standards (now called the National Institute of Standards and Technology). The 1954 edition of NBS Handbook 59 adopted the term "permissible dose" in preference to the former term, "tolerance dose," because, as they put it:
 - (i) "Since it seems well established that there is no threshold dose for the production of gene mutations by radiation, it follows that strictly speaking there is no such thing as a tolerance dose when all possible effects of radiation on the individual and future generations are included."
- (b) A 1957 change extended this non-threshold concept to somatic effects of radiation, and it reemphasized the NCRP's "long-standing philosophy that radiation exposures from whatever sources should be as low as practical."
 - (i) The 1954 edition of Handbook 59 "Permissible Dose from External Sources of Ionizing Radiation" has the following paragraph:
 - 1) "The present report deals primarily with the protection of persons occupationally exposed to ionizing radiation from external sources. An attempt has been made to cover most of the situations encountered in practice. However, it has not always been possible to make recommendations in quantitative terms. In such cases, the recommendations are intended to serve as practical guides. The recommendations are based on presently available information and cannot be regarded as permanent. For this reason and on general grounds it is strongly recommended that exposure to radiation be kept at the lowest possible level in all cases."
- (c) It seems that early the philosophy was based on the dynamics of new and fast-changing recommendations of limits (tolerance versus permissible doses) and thresholds, as compared to it being based on the later linear no-threshold (LNT) theory.
- (d) In an Atomic Energy Commission (AEC) (predecessor to NRC) Statement of Consideration (SOC) published 3 December 1970, 35 FR 18385, the proposed regulation addressed control of releases of radioactive material to the environment. This Statement indicates that on 1 April 1970, the AEC published in the Federal Register (35 FR 5414) a proposed amendment to Parts 20 and 50 which would, inter alia, improve the framework in 10 CFR Part 20 for assuring that reasonable efforts are made by all licensees to continue to keep exposure to radiation, and releases of radioactive effluents, as low as practicable. This philosophy, SOC continues, was based on the Federal Radiation Council's (FRC) recommendations. FRC was established around 1959, and the SOC mentions its Report No.1 dated 13 May 1960.

⁵ Jones, DeCicco, Sherbini, (9/2009). Answer to Question #8375 Submitted to "Ask the Experts" [Health Physics Society]. Retrieved from URL: <https://hps.org/publicinformation/ate/q8375.html>

- (e) In addition, between 1975 and 1976, the term in 10 CFR 20.1(c) changed from "as far below the limits specified in this part as practicable" to "as low as reasonably achievable." It stated in 20.1.(c):
 - (i) "In accordance with recommendations of the Federal Radiation Council, ... persons engaged activities under licenses issued by the NRC ... should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted area, as low as reasonably achievable."
- (f) The next sentence goes on to expand for clarification that the concept considers the state of technology, economics of benefit versus risk, and other societal and socioeconomic considerations.
- (g) As for the last part of the question, ALARA is a general requirement for all NRC licensees, since Part 20 applies to all licensees, and therefore is applied in all NRC-licensed activities. All licensing organizations, such as other federal agencies and the states, also have it as a requirement. Application of the requirement, though, may not be uniformly stringent or equally visible in all industries, for a number of complex reasons.
- (h) The design objectives in Part 50, Appendix I, were issued in 1975, and these were based on application of the idea of ALARA. However, this application differs from what we now understand the term to mean because, at that time, the design criteria were selected by NRC staff after applying cost-benefit considerations and then using these considerations to formulate the final rule. The requirement to keep doses ALARA as a basis for radiation protection in general was as indicated above.

Section 8.02 Regulatory Limits

- (a) Dose Limits
 - (i) The maximum permissible exposures, stated below, should not be assumed to be tolerable exposures. They represent upper limits to which individuals might be exposed, and that exposure to those limits shall be avoided in keeping with the principles of ALARA noted above.
 - (ii) Dose Limits from External and Internal Exposure
 - 1) Internal exposures (from inhalation and ingestion) shall be included when determining occupational doses when required.
 - 2) A person of age 18 or older who is routinely subjected to work involving radiation is an occupational worker.
 - 3) No user shall possess sources of radiation in such a manner as to cause an annual dose in excess of:
 - a) *For individuals 18 years of age or older:*
 - i) *Whole Body* - 5 Rem (0.05 Sv)
 - ii) *Any organ other than the lens of the eye* - 50 Rem (0.5 Sv)
 - iii) *The skin or the extremities* - 50 Rem (0.5 Sv)
 - iv) *The lens of the eye* - 15 Rem (0.15 Sv)
 - b) *For individuals under 18 years of age to receive an dose in excess of 10% of the limits specified above*

- 4) For the purposes of this program a “controlled area” shall be defined as any area where expected exposure would exceed public dose limits from projects requiring approval by the RSC.
 - 5) Each user shall require any individual, prior to first entry into any controlled area maintained by the user where internal dose assessment or personnel monitoring is required to disclose in a signed statement, either:
 - a) *That the individual had no prior occupational radiation exposure during the current calendar year;*
or
 - b) *The nature and amount of any occupational radiation exposure which the individual may have received during that current calendar year.*
- (iii) Dose to an Embryo/Fetus (Declared Pregnant Women)
- 1) Each user, as specified in 10 CFR Section 20.1208, shall ensure that the dose to an embryo/fetus during the entire pregnancy, due to exposure of a declared pregnant woman - who has voluntarily informed the user, in writing, of her pregnancy - does not exceed 0.5 rem (5 mSv).
- (iv) Exposures to Members of the Public
- 1) The total effective dose equivalent to individual members of the public from the authorized operation does not exceed 0.1 rem (1 mSv) in a year, and
 - 2) The dose in any unrestricted area from external sources does not exceed 2 millirems (0.02 mSv) in any one hour.

Article IX. Basic Radiation Safety Principles and Work Rules

Section 9.01 Control of External Exposure

(a) External radiation exposure from a given radioactive source is controlled by the distance from the source, the exposure time, and shielding.

(i) Distance

Increasing the distance from the source is frequently the most effective and economical means to reduce radiation exposure. Radiation fields vary inversely with the square of the distance from a small or "point" sources, see figures 7.01a and 7.01b below:

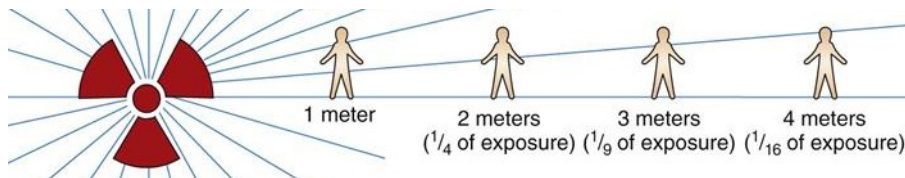


FIGURE 7.01A

$$\frac{I_1}{I_2} = \frac{D_2^2}{D_1^2}$$

FIGURE 7.01B⁶

For this reason, tongs or other long-handled tools should be used for manipulating radionuclide preparations emitting significant levels of radiation. Low-level sources can be handled with short forceps which provide a large reduction in exposure when compared with direct skin contact.

(ii) Time

Decreasing the time of exposure decreases the radiation dose proportionately. It is important to include "dry runs" with non-RAM for critical steps in preplanning of all work which may involve substantial radiation exposure.

(iii) Shielding

Shielding the source of radiation will be necessary when the maximum distance and minimum time do not insure an acceptably low exposure to operating personnel.

⁶ WHERE:

I₁= Intensity 1 AT D₁

I₂= Intensity 2 AT D₂

D₁= Distance 1 from the source

D₂= Distance 2 from the source

1) Gamma Shielding

Interposing materials, preferably of high atomic number and high density, between the source of radiation and the area to be shielded. Common examples include:

- i) Lead*
- ii) Iron*
- iii) Steel*
- iv) Copper*
- v) Aluminum*

2) Beta Shielding

Interposing materials, preferably of low atomic number and low density, between the source of radiation and the area to be shielded. Common examples include:

- i) Polyethylene*
- ii) Polystyrene*
- iii) Polypropylene*
- iv) Polycarbonate*

3) Alpha Shielding

Interposing any materials of a thickness equal to or greater than a piece of paper are usually sufficient to provide adequate shielding to sensitive portions of the body where skin alone does not provide adequate protection between the source of radiation and the area to be shielded. An example where skin does not provide adequate shielding from alpha sources could include the surface of the eye.

4) Sequencing of Shielding and Special Considerations

- a) Where RAM emits both beta and gamma radiation, shielding considerations will need to be made taking into account for all types of radiation. Beta radiation has the potential to produce penetrating X-rays through bremsstrahlung. The intensity of bremsstrahlung varies directly with the square of the energy of the beta radiation and the average atomic number of the shielding material. Low atomic number materials such as Lucite or glass should, be used for shielding of beta radiation sources first to reduce the potential additional bremsstrahlung by subsequent high z shielding used for gamma radiation sources.*
- b) When working with energetic beta emitters, care must be taken to avoid exposing hands above opened shielded containers where the dose rate can be on the order of rads per minute for commonly used quantities of beta emitters such as Phosphorus-32.*

Section 9.02 Control of Internal Exposure

- (a) Distance, time and shielding are obviously not available for protection when the source of radiation may be internally deposited in the body. Incorporation of RAM into the body is controlled by preventing uptake into the body of unsealed sources of RAM. In order to reduce the potential for internal exposure the following industrial hygiene practices shall be implemented where a significant potential for internal dose is identified during the hazard assessment:
 - (i) All RAM easily dispersible in air must be used inside properly designed and operating exhaust-ventilated enclosures designated for that purpose.
 - (ii) Protective clothing consisting of laboratory coats and appropriately impermeable gloves shall be worn when working with RAM.
 - (iii) Hand washing when leaving the lab.

- (iv) No food, drink, cosmetic application, smoking/vaping or gum chewing in any lab.
- (v) Lab coats shall be laundered no less than once a semester, and each time contamination is identified or suspected. Gross contamination of lab coats may render them not launderable, and replacement and disposal in accordance with radioactive waste requirements be required.

Section 9.03 Work Practices

- (a) The following rules of good radiation protection practice shall be implemented by users to prevent unnecessary radiation exposure and minimize contamination.
 - (i) Store and transport containers of easily dispersible radioactive materials in rigid outer containers sufficiently durable to withstand the expected forced during an accident, and are capable of containing the contents of the primary container in the event of breakage. Accidents, in this instance, include no less than being dropped on a hard surface from approximately forty-two inches above the surface below the material.
 - (ii) Line trays and working surfaces where easily dispersible radioactive materials are used with impermeably backed absorbent paper.
 - (iii) All containers of easily dispersible radioactive materials remain closed when not adding or removing of source materials from the container.
 - (iv) Clearly label all containers of RAM with the words, "Caution - Radioactive Materials" the isotope, approximate activity, and date of the approximate activity and the required trefoil symbol.
 - (v) Post all radiation and storage areas with the standard radiation warning trefoil symbol and the words, "Caution - Radiation Area" or " Caution - Radioactive Materials", whichever is appropriate for the location in question.
 - (vi) Conduct work in accordance with project approvals only.
 - (vii) Train or familiarize users that have not previously carried out new procedures in a "dry run" with simulated non-RAM materials before using RAM whenever possible.
 - (viii) Monitor work areas and where dispersible radioactive materials are used after each procedure where there is any possibility of contamination and otherwise on a regular periodic basis. Keep records of such surveys.
 - (ix) Clean up spills promptly.
 - (x) No food, drink, cosmetic application, smoking/vaping or gum chewing in any lab.
 - (xi) Do not allow fingers or other objects to enter or be near the mouth.

Article X. Hazard Assessment

Section 10.01 Estimation of Exposure

- (a) The RSO shall provide to the RSC for review, during the new project approval process, a preliminary hazard assessment of exposure to registered users, or members of the campus community.
- (b) RSC members are encouraged to provide insight and expertise on those project where their knowledge and expertise is needed to accurately predict if the likelihood of exposure is in keeping with the concept of ALARA and applicable regulatory limits.
- (c) Using the data presented in the preliminary or subsequent reviews of the hazard assessment shall be used to:
 - (i) Determine if area monitoring is appropriate, and make specific recommendations if they have expertise or knowledge on that topic.
 - (ii) Determine if personal monitoring of registered users is appropriate and make specific recommendations if they have expertise or knowledge on that topic.
 - (iii) Provide recommendations for instrumentation, or review of those proposed, to be used to detect contamination or leaks if they have expertise or knowledge on that topic.
 - (iv) Develop new project approval recommendations, or requirements to conditionally approve those projects if appropriate, for substitution, engineering, administrative, or personal protective equipment controls to ensure doses remain ALARA or below applicable regulatory limits.

Article XI. Accidents, Overexposures, and Contamination

Section 11.01 Reporting

- (a) In the event of actual or suspected overexposure to radiation, inhalation or ingestion of RAM, or contamination of person or facility:
 - (i) The RSO must be notified immediately.
 - (ii) The RSO is required to report incidents/overexposures, etc., to the California Department of Public Health.

Section 11.02 Radiation Accidents

- (a) External Radiation Exposure
 - (i) A person receiving or suspected of receiving a significant exposure to external radiation; i.e., where the source of radiation remains external to the body, shall be removed promptly from the hazardous area, and the RSO notified immediately.

Section 11.03 Radioactive Contamination - Area

- (a) Major Contamination Involving Potential Health Hazard
 - (i) In the event of spreading or suspected spreading of radioactive contamination over a significant portion of a room or large area:
 - 1) Vacate the area, leaving behind clothing and other articles which may be contaminated.
 - 2) Have general ventilation systems turned off, where applicable.
 - 3) Call the RSO immediately.
 - 4) If a suitable monitoring instrument is available, evaluate the degree of contamination of personnel.
- (b) Minor Contamination Involving No Significant Health Hazard
 - (i) Minor radioactive contamination of work surfaces, floors, walls or equipment should be dealt with promptly but carefully.
 - (ii) When feasible the RSO should be notified prior to effecting decontamination. Possible dangers include a person contaminating himself in cleaning up a spill or in creating a worse problem than existed before e.g., by flushing contamination deeper into porous material such as wood.
 - (iii) The RSO must be notified, if not done in advance, of a decontamination procedure being carried out so that the affected area may be inspected for any residual contamination.

Section 11.04 Radioactive Contamination - Personnel

(a) Skin Contamination

Thorough washing with soap and water is the best general method for decontamination of the hands and other parts of the body, regardless of the contaminant. If the contamination is localized, it is often more practical to mask off the affected area and cleanse with swabs, before risking the danger of spreading the contaminant by general washing. Skin decontamination must continue until no removable contamination remains. In the event detectable fixed contamination remains, the RSO must be called before the affected individual may leave the premises.

(b) Contaminated Wounds

(i) Persons cut by glassware, injured by hypodermic needles or contaminated instruments, etc., shall wash the injured part under continuous stream of water immediately following the injury. Do not delay in reporting the injury to the RSO as any delay may greatly lessen the effectiveness of subsequent treatment.

(c) Internal Contamination

(i) Persons whom are suspected to have had an acute internal dose, for instance accidental swallowing or injection of an isotope are required to seek medical attention. It is strongly suggested that a printed copy of NCRP Report No 161-I be available to lab workers to take to the emergency treatment facility where open sources or those that are easily dispersible into the environment and subsequently easily taken up by the body are present.

Article XII. Radiation Monitoring

Section 12.01 Routine Surveys

- (a) The RSO shall be responsible for making periodic surveys of all areas in which unsealed radioisotopes are used. Such surveys will be made as frequently as deemed necessary, usually at least once a month. In addition, registered users may be required to survey at the end of every work day or when finished, whichever one comes first, and to log each survey in a logbook.

Section 12.02 Special Monitoring

- (a) Registered users are responsible for notifying the RSO in advance of an experiment or procedure which could involve a significant ionizing radiation hazard. Details related to exposures of this nature and the requirement to notify the RSO shall be spelled out in the procedure approved by the RSC. The RSO will provide special monitoring when necessary. When there is any doubt as to when the RSO should be notified, this should be resolved in favor of notification.

Section 12.03 Personal Monitoring

- (a) As required under Title 10 CFR Section 20.1502, each radiation worker shall wear the appropriate dosimetry and/or other personal monitoring instruments whenever there is the potential of receiving an exposure dose in excess of 10% of the limits specified in the corresponding regulatory dose limitations sections of this document.

Section 12.04 Dosimetry

- (a) Each department or group will be responsible for obtaining personnel dosimetry if required. All exposure reports must be made available to the RSO. Personal exposure records will be maintained for all monitored personnel. Some personnel receive film badges on a precautionary basis, which are reviewed quarterly to verify deep tissue dose is ALARA and identify problems.
- (b) Radiation Producing Machines
 - (i) Employees are responsible for notifying the RSC of the purchase and installation or modification in the installation of any machine capable of producing ionizing radiation for any reason. A radiation survey shall be made by the RSO or a duly authorized representative of the RSC prior to placing any such machine in service. Registration of radiation producing machines with California Department of Public Health – Radiologic Health Branch is required when the production of radiation is the primary purpose of the device, and shall be paid by the department operating the equipment.
- (c) Sealed Radioactive Sources
 - (i) Periodic leak tests of all sealed radioactive sources shall be made by the RSO, as required by the Title 17 Section 30275. Each sealed source, other than those listed in Section 30275 as exempt from testing, shall be tested for contamination prior to initial use and for leakage at least every six months. Contamination tests shall be capable of determining the presence of 0.005 μCi of removable contamination.

Section 12.05 Radiation Detection Equipment

- (a) Possession and Operation

- (i) All approved projects are required to have adequate radiation detection equipment available when determined by the RSC necessary for exposure prevention. The RSC shall establish what constitutes adequate detection equipment during the project application approval process. It is the responsibility of the registered user to ensure detection equipment is available and maintain it in working condition while approved project components capable of resulting in radiation exposure are in their possession and operational.
- (b) Calibration
 - (i) Required radiation detection equipment shall be calibrated by an approved outside agency annually.
 - (ii) It is the responsibility of the registered user to ensure that required calibration is completed for periods of time when RAM radiation producing equipment is in the possession of the Registered User. Radiation detection equipment used for instructional demonstration and research are not required to be calibrated if the intended use of those instruments does not include exposure monitoring, contamination detection, or hazard assessment. Before an inactive meter may be placed back in service, it must be re-calibrated by an approved outside agency if that has not been done within the past year.

Section 12.06 Decommissioning and Decontamination

- (a) A notification will be required prior to vacating a restricted area and returning it to a non-restricted access location. A clearance survey will be performed with limits of 200 dpm/100cm² removable contamination and 0.05 mR/hr exposure rate. Survey results will be provided to the RHB upon request.

Article XIII. Current Radiation Detection Instruments Available to Conduct Surveys and Hazard Assessments

Section 13.01 Instrument list⁷:

(a) The following devices are maintained by the RSO for use in the radiation safety program located in radiation safety analytical lab:

- | (i) Make & Model | Description |
|-------------------------------|---|
| 1) Technical Associates PUG 7 | β / γ Handheld GM detector |
| 2) Ludlum 3030m | α / β mobile well counter |

(b) The following devices are maintained by the Biology Department for use in the radiation safety program located in Science I 303A:

- | (i) Make & Model | Description |
|--------------------|---|
| 1) Beckman LS 6500 | α / β liquid scintillation counter |

⁷ All instruments calibrated annually by manufacturer(s).

Article XIV. Revision History

Revision	Date	Revised By	Description
0	10/31/18	M. Burgess	Added common duct prohibition information.
1	1/08/19	M. Burgess	Added revision history page.
2	9/12/2019	M. Burgess	Required Annual Review. Tracking changes/history turned on and pass worded to prevent it from being turned off. To be forwarded to RSC for review. Significant changes were made throughout the documents.
3	11/25/2019	M. Burgess	Corrected minor spelling and grammatical errors suggested by RSC Committee chair M. Gherase.
4	6/18/2020	M. Burgess	Fixed typo on the table of contents where section 7.10 was not included in the TOC.