COLORADO SCHOOL OF MINES
EARTH • ENERGY • ENVIRONMENT

Radiation Protection Program

2012

Environmental Health and Safety Department

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PREFACE

This document is designed to provide practical safety and regulatory guidance to ionizing radiation users at the Colorado School of Mines (Mines). Details on the regulations and specific radiation guidance can be found in the Mines Environmental Health and Safety (EHS) Department/Radiation Safety Office.

The Mines EHS/Radiation Safety Office has a set of operating instructions entitled, “Health Physics Instructions” (HPIs). These provide guidance to Mines radiation safety personnel. As these may have impact on a radiation user’s program and may provide detail on safety procedures, users are encouraged to review these instructions.

1. INTRODUCTION

1.1. Purpose

This document outlines the Radiation Protection Program of the Colorado School of Mines. The program includes official policies regarding the use and possession of radioactive materials and radiation producing equipment on the School's campus.

All research or other activities that involve ionizing radiation at the School must comply with the Colorado Department of Public Health and Environment's (CDPHE) *Rules and Regulations Pertaining to Radiation Control* and any licensing conditions and registrations.

1.2. ALARA Philosophy and Policy

The acronym ALARA stands for **A**s **L**ow **A**s **R**easonably **A**chievable. This phrase refers to a principle of keeping radiation doses as low as can be achieved, based on technologic and economic considerations. Federal and state regulations require written radiation protection programs be developed and implemented following the ALARA philosophy. The goal of the Mines radiation protection program is to keep public and occupational radiation doses ALARA on the Mines campus. ALARA is a code of professional ethics and a safety culture to which the School's radiation users are expected to adhere.

1.2.1. Applied practices

ALARA principles are commitments to safety by all parties involved in the use of radiation at the School. These include a wide range of easily applied practices. Various sections of the Radiation Protection Program address user responsibilities and the safe handling, storage, use, transport and disposal of radiation sources.

2. EMERGENCY PROCEDURES

2.1. Emergency Contact Information

EHS Department (24 hour)	**303-273-3316**
EHS Director (cell)	303-807-7293
Radiation Safety Officer (cell)	303-324-0589
CSM Public Safety	**911 or 303-273-3333**
Golden Police/Fire Department	**911 or 303-384-8045**

2.2. Radiation Emergency Procedures

<u>Immediately</u> notify EHS in the event of a Radiation Emergency.

<u>Call 911</u> in the event of fire, explosion, injury, or other life threatening conditions.

The School maintains an Emergency Response Team which manages incidents involving radioactive materials. Specific emergency response procedures are described in three internal documents. Copies of these documents are available in the EHS Departmental Office in Chauvenet Hall. These documents are:

a) Hazardous Materials Response Plan
b) Emergency Procedures and Contingency Plan
c) Preparedness and Prevention Plan

2.2.1. Notifications

In the event of an emergency involving radiation, EHS should be notified as soon as possible. If the emergency is life threatening, Mines Public Safety (911) should be contacted. Be sure to indicate that radiation is involved. Have the following information available for emergency personnel:
1. **Your name** and the **name of the Authorized User** in charge of the laboratory.
2. Type of **radiation incident** (e.g., spill, X-ray malfunction, lost sealed source, etc.).
3. The **location** of the incident (e.g., building, room number, location of spill or machine in the laboratory).
4. A **phone number** where you can be reached, as well as the **location** where you will meet emergency personnel.
5. The **radioisotope** (or **energy** if an X-ray machine).
6. The estimated **activity** involved.
7. The **volume** of material involved.
8. The **chemical form** of the compound.

2.2.2. Procedures for Spills – Major

There are large spills and small spills. **Large spills involve alpha emitters of >1 µCi and beta/gamma emitters of > 100 µCi.** For large spills, users should follow this simple guide.

If a medical emergency is associated with the radiological emergency, GET MEDICAL HELP IMMEDIATELY. Radiation emergencies are rarely life-threatening, and the medical emergency always takes precedence.

Stage	*Action*	*By*
STOP	Assess the situation.	Any involved person
WARN	**Let everyone in the vicinity know about the emergency**. Be emphatic.	Any involved person
ISOLATE AND CONTAIN	If applicable, prevent spread of material and contain the spill, e.g. use absorbent material. Limit movements of potentially contaminated people. Use protective personal equipment as appropriate such as gloves.	Any involved person
MINIMIZE EXPSOURE	This may be accomplished by methods as simple as moving a sufficient distance from the RAM or by placing a shield of sufficient material (ex. door), between you and the source to attenuate the radiation.	Any involved person
INFORM	Notify immediate supervisor Notify EHS (Phone ext. -3316) CSM Police, at **911,** (indicate it is a radiation emergency)	Any involved person
EHS and support will perform the following		
ASSESS	Investigation and assessment	Radiation Safety
DECISION	Declare emergency and determine involved area	Emergency Director, RSO, or designate.
RESPONSE	1. Activate and assure appropriate responses 2. Rad assessment, supply, protection, and corrective action 3. Notification, corrective actions 4. Evacuations and communications	1. RSO 2. HP 3. Line operations 4. Staff support
RECOVERY	1. Declare termination 2. Plan for future	1. RSO 2. All units

2.2.3. Procedures For Spills – Minor

2.2.3.1. Do not enter an area where radioactive vapors, gas or mist may be present. Call EHS and restrict access to the area.

1. Notify all persons not involved in the spill to vacate the room. Notify EHS. Generally, the user is expected to manage small spills, but EHS/Radiation Safety will be happy to assist.

2. Determine Exposure Rate – Using an appropriate survey meter, determine if the unshielded waste is producing an elevated radiation field. If the exposure rate is >5 mR/h, evacuate immediately and contact EHS.

3. Don PPE – Don personal protective equipment necessary to clean up the spill safely. Erect shielding to protect your head and body while cleaning the spill. If fumes, gases or strong odors are present, evacuate the area and call EHS for assistance.

4. Apply Absorbent (if necessary) – If the spill may become unconfined, quickly apply absorbent. Cover small spills with paper towels or dike larger spills with absorbent working from the edge of the spill toward the center. NOTE that some liquids may react with absorbents. You may have to use a neutralizing absorbent. **Do not contaminate yourself while containing the spill.**

5. Restrict Access to the Spill – Erect barriers using chairs, barrier tape, etc. to restrict access to the area. Post signs if necessary. You must prevent others from tracking through the contaminated area.

6. Mark the Area of the Spill – Indicate the perimeter of the obvious area of contamination. Use tape, sharpies, etc. to clearly define the contamination zone. Use a survey meter to locate hot spots. Mark these as well.

7. Clean up Spill – Carefully sweep up absorbent into a dustpan or pick up paper towels and transfer the debris into a plastic bag. Place absorbent pads into the bag, carefully check for glass. Apply a disinfectant solution if the spill contains a biohazardous material. Allow it to soak for 20 minutes. Apply a small amount of detergent solution and clean the contaminated area. **Do not spread the contamination**. Place all scrub pads, paper towels, etc. in the waste bag. Use a survey meter to monitor the progress of the clean up process.

8. Wipe Test – Don clean gloves and perform a wipe test. Place the wipe containers in secondary containment that will not be contaminated.

9. Manage Clean Up of Waste – Carefully remove your PPE and dispose of it in the waste bag. Seal the bag with tape and leave it in the restricted area. Do not remove anything until the wipe results are complete.

10. Personal Exit Survey – Survey yourself carefully. Remove any contaminated clothing and survey your skin. If skin contamination is

evident, start decontamination procedures immediately by washing with detergent and large volumes of water. Contact EHS for any case of skin contamination.

11. Evaluate the Wipe Test – Determine if the clean up effort was successful. Are there any spots with removable activity? If so, contact EHS for advice/assistance to complete the decontamination. If the wipes are not significantly higher than background, perform a final surface survey with an appropriate survey instrument to determine the level of fixed radioactivity. Contact EHS in any case where there is fixed activity.

3. USER DEFINITIONS AND RESPONSIBILITIES

3.1. Mines Management

Mines management includes the School's President, the Director of the Environmental Health and Safety (EHS) department, and the supervisors of Authorized Users such as Department Heads. Management is responsible to

1. Support the ALARA policy and the Radiation Safety Program
2. Be aware of ionizing radiation uses on campus
3. Assure that ionizing radiation is being safely used

3.2. Radiation Safety Officer

The Radiation Safety Officer (RSO) is a member of the Environmental Health and Safety (EHS) department and is the individual named on the School's radioactive materials license. The RSO supervises the use of radiation on campus and reports to the Director of the EHS department. The RSO is responsible to:

1. Be the lead in assuring adherence to ALARA
2. Assure adherence to all radiation regulations issued or subscribed to by the School.
3. Implement the organization, administration and management of the School's Radiation Safety Program.
4. Interpret regulations which govern the uses of ionizing radiation and disseminate information on radiation safety.
5. Interact with regulatory agencies and assure that Mines is properly licensed for ionizing radiation uses including licenses and registrations.
6. Approve new authorized users and radiation workers. Maintain an accurate database of approved users and their training.
7. Review and approve new proposals for radiation use and assure that regulatory requirements are met.
8. Coordinate the dosimetry service, maintain personnel exposure records, and give timely notice of over-exposures to the individual, the individual's supervisor and regulatory agencies when appropriate.
9. Review and approve procurement requests for radioactive materials and radiation producing machines to assure compliance with limitations for possession and use.
10. Maintain an accurate inventory of radioactive materials and radiation producing equipment. Maintain records of radioactive materials and radiation producing equipment transfer, storage or disposal
11. Instruct radiation users and Mines employees on radiation safety.
12. Manage the radioactive waste disposal program and maintain disposal records.
13. Conduct periodic radiation safety surveys of radioactive material and radiation producing equipment uses and locations.
14. Perform required sealed source leak tests and report abnormal results
15. Assure the appropriate calibration of portable monitoring and survey equipment.
16. Report to appropriate authorities and any reportable radiation incident or event which may have resulted in injury, contamination or damage to property.
17. Delegate duties and responsibilities to qualified personnel.

3.3. Authorized Users

An Authorized User (AU) is faculty member, approved by the RSO, and responsible for the proper use, storage, handling, and disposal of regulated radioactive materials or radiation producing equipment under their aegis. To possess radioactive materials, the faculty member must apply to the RSO for authorization. Radiation producing equipment Authorized Users must demonstrate to the RSO that he/she has the appropriate training to use the equipment. Applicant faculty members may be required to provide documentation of training and experience which qualifies them to possess the desired material. NOTE: Radioactive material Authorized Users must be specifically identified in the School's radioactive materials license. Authorized Users are responsible to:

1. Assure adherence to the ALARA policy for the uses of radiation under their aegis. Ensure compliance with applicable radiation regulations.
2. Supervise staff members and students in handling radioactive material or using radiation producing equipment.
3. Designate supervised users and assign to function in subordinate user categories noted in Sections 3.4 through 3.7 below.
4. Assure radiation workers and ancillary personnel are properly trained in accordance with training requirements in Section 4 below.
    a. Coordinate with the RSO to assure sufficient radiation safety training
    b. Provide awareness training when appropriate
5. If required, ensure that workers wear personal dosimetry and submit bioassays samples.
6. Ensure that no eating, drinking, food preparation or storage, application of cosmetics or smoking occurs in radiation use areas.
7. Ensure the proper planning of an experiment or procedure and ensure that adequate safety precautions are observed.
8. Maintain required and accurate records of receipt, use, storage and disposal of radiation sources. Maintain records of required surveys.
9. Maintain security by assuring the radioactive materials are secured against theft, misuse and access by unauthorized personnel.
10. Report immediately to the RSO theft or loss of radionuclides and major radiation accidents from materials or radiation producing equipment. Inform the RSO of minor radioactive material spills.
11. Communicate to the RSO all pertinent information regarding changes in their authorization.
12. Assure that the equipment supplies and services necessary for radiation protection are provided.
13. Assure that radioactive wastes are segregated properly and placed in appropriate containers. Containers are to be provided by EHS.

3.4. Independent Supervised Users

The RSO designates persons as Independent Supervised Users (ISU). This qualification is assigned upon completion of the radiation safety training or when the RSO is satisfied that the applicant has prior experience and training that is equivalent to the completion of the course. ISUs may handle radioactive material under the guidance and direction of the Authorized User; however the Authorized User need not be present to personally oversee the activities of the ISU. The ISU is responsible to:

1. Ensure that no eating, drinking, food preparation or storage, application of cosmetics or smoking occurs in radiation use areas.
2. Keep his/her radiation exposure as low as reasonably achievable utilizing time, distance, shielding and contamination control techniques as appropriate.

3. Survey hands, shoes, body and clothing for radioactivity and decontaminate before leaving the lab (for radioactive material users working with unsealed sources).
4. Check work areas at the end of each work session for contamination and decontaminate as necessary (for users working with unsealed sources). Maintain survey records as required.
5. If required, wear personal dosimetry and submit bioassay samples.
6. Use recommended or required personal protective equipment and equipment such as protective clothing, eye shields, gloves, shielding, glove boxes, respiratory protection, etc.
7. Maintain an accurate inventory of radioactive materials.
8. Maintain security of radionuclides both while in use and in storage.
9. Properly dispose radioactive wastes and maintain disposal records.
10. Report immediately to the AU and the RSO any accident involving radioactive materials or radiation producing equipment.
11. Assure dose rates in work area are ALARA and assure ancillary personnel do not get excessive exposures (> 50 mrem/yr or 2 mrem/hr).

3.5. Directly Supervised Users

Directly Supervised Users (DSU) are persons who have not completed a radiation safety training course. Directly Supervised Users may not handle radioactive materials except under direct supervision of the Authorized User or RSO. It should be a relative rare situation for a person to be designated as a DSU, but it is sometimes necessary for short term visiting researchers or other situations. The AU is wholly responsible for the DSU's safety. The AU or RSO must provide awareness training to the DSU and assure that the DSU does not exceed 100 mrem in a year.

3.6. Ancillary Personnel

Ancillary Personnel (ANP) are individuals whose duties include working in the presence of any licensed radiation source or require unaccompanied access to controlled radiation use areas. Ancillary Users are not permitted any direct involvement with the use of any radiation source. The AU, or designee, must assure that the ancillary person receive awareness training. The RSO routinely gives awareness training to some ancillary personnel such as facility personnel and custodians. This may be applied to the ancillary personnel training, but the AU or ISU is responsible to point out areas where ancillary personnel need to take caution or are not allowed to enter.

3.7. Radiation Producing Equipment Supervisor

Radiation producing equipment (RPE) includes X-ray machines and particle accelerators. A qualified faculty member shall be responsible for the use and maintenance of each item of radiation producing equipment. The supervising faculty member is responsible to

1. Provide safety training to staff members and students who are authorized to operate the equipment.
2. Assure that only persons who are authorized and trained by the supervising faculty member are allowed to operate radiation producing equipment.
3. Assure that the RPE is installed in a safe manner such that it assures safety for workers and those who may be near the equipment.
4. Assure that safety mechanisms on the RPEs are functional and operating correctly.
5. Assure that the RPE is registered with the State of Colorado if required.

6. Assure that regular inspections of the RPE are performed.
7. Report to RSO any modifications, repairs, replacements and maintenance on the RPEs. Report to RSO any status changes including transfer, lost/stolen, or out of services.
8. Assure proper dosimetry is used.

3.8. Radiation Producing Equipment Operators

Operators of RPE are responsible to

1. Understand operating procedures and safety precautions.
2. Assure that operations are conducted safely.
3. Check that safety devices are working properly.
4. If required, wear personal dosimetry.

4. RADIATION SAFETY TRAINING

4.1. Rules and Regulations

Regulations governing the possession and use of radioactive materials and other radiation sources require that every individual working with or in the presence of such sources be instructed in the applicable provisions of regulations and license conditions, in the potential health problems associated with exposure to radiation, in the precautions and procedures required for safe use of radiation, and in the proper use of protective and measurement devices. The extent of the training is to be commensurate with the potential risk of radiation exposure to the individual.

The primary responsibility for providing adequate training for individuals who work routinely with radiation sources rests with the Radiation Safety Officer, Authorized User or Supervisors. For individuals who are only occasionally exposed to radiation, e.g. custodial, maintenance, security and delivery personnel, the responsibility for training lies with their supervisors.

The RSO is responsible for developing, conducting, and documenting radiation protection training applicable to all categories of radiation users. For each category of users, the RSO shall establish an appropriate schedule or frequency and the minimal requirements for content of the program. The RSO shall maintain appropriate records of training offered and completed to assure compliance with regulatory requirements.

The Authorized Users or supervisors will fulfill their responsibility by assuring that each person attends the appropriate training offered by the RSO. The Authorized User may also provide training and keep records of the individuals trained and the content of the training.

4.2. Training Module Content

The RSO offers five general radiation training modules and guidance on awareness training. The AU is responsible for providing the in-lab specific safety training module (Module 6). The modules are offered when there are new radiation users or current users of radioactive materials require an upgrade in their level of qualification. Modules 1 through 5 are conducted in a classroom setting. A written examination is to be taken by individuals following the completion of the modules. This examination is a closed-book in-classroom activity with a passing score of 70%. Module 6 is completed in the lab by the AU and is tailored to the lab activities specific to the research the individual will be conducting. There is no examination required for this module. The RSO may modify the modules at any time but basic content shall remain the same.

Module 1 - “Introductory Radiation Safety Training”

This module provides all the necessary training required by the Colorado Department of Public Health and Environment (CDPHE) *Rules and Regulations Pertaining to Radiation Control*.

Module 2 - "Physics Review"

This module provides basic radiation physics and health physics information.

Module 3 – "Radiation Interactions with Matter"

This module provides basic information on how radiation interacts with matter, appropriate shielding and radiation detection devices.

Module 4 – "Biological Effects of Radiation Exposure"

This module provides information on the effects of external radiation exposure.

Module 5 – "External and Internal Radiation Dosimetry"

This module provides information on the effects of internal radiation exposure.

Module 6 – "Safe Lab Practices"

The objectives of this module are lab specific to:

1. Review ALARA principles.
2. Review lab safety procedures and emergency procedures.
3. Review routes of entry and personal protective equipment.
4. Discuss in-lab record keeping and documentation.
5. Review waste collection practices.
6. Demonstrate relevant procedures in the laboratory setting.

Awareness Training

The objectives of this training are to inform those not using radiation in a lab about the radiation hazards in the lab. The training content includes

1. Signage recognition.
2. Location of radiation sources.
3. What to do in an emergency.

4.3. Training Procedure

4.3.1. Authorized User (AU) initiates "CSM Radiation User Information" form. AU determines user's category and sends form to RSO. Alternately, the AU can send the new user to the RSO for direct evaluation.

4.3.2. RSO reviews form and analyzes for dosimetry and training needs. RSO schedules training and initiates data entry.

4.3.3. Users receive training in accordance with their classification and needs.

Module 1: All new users of licensed radioactive materials (not including general-licensed materials) are required to attend Module 1 training. This module is only required to be attended once. Module 1 meets the requirements of the State of Colorado 6 CCR 1007-1.10.3 "Instructions to Workers".

Module 2: All prospective users of radioactive sources who require training concerning the fundamentals of nuclear physics must take Module 2.

Module 3: All prospective users of radioactive sources who require training concerning radiation interactions with matter must take Module 3.

Module 4: All prospective users of radioactive sources who require training concerning biological effects of radiation exposures must take Module 4.

Module 5: All prospective users of radioactive sources who require training concerning radiation dosimetry must take Module 5.

Module 6: All prospective users of radioactive sources who require training concerning safe laboratory practices must complete Module 6. The AU (RSO may assist) will tailor the training to the lab's activities - specific to the research the individual will be conducting.

Awareness Training. The RSO, AU, designee or worker's supervisor shall give a awareness training to ancillary personnel, visitors, maintenance workers or other person's not using radiation who enter the lab. The RSO should provide awareness training to emergency response personnel.

4.3.4. RSO completes the "User Agreement and Authorization" form as applicable and updates the radiation safety training database.

5. RADIATION USE AUTHORIZATION

5.1. Licensing

To become an Authorized User, a first-time applicant should contact the RSO to set up a time to discuss the scope of proposed research activities, related licensing regulations, training requirements and the approval process.

The RSO will guide the applicants through the process and provide a "Radiation License Amendment Proposal and Safety Plan Application" form and any other appropriate forms. Faculty members who wish to start a new project using radioactive material on the campus must also complete an "Authorized User's Training and Experience" form.

Each proposed use of radioactive materials, X-ray or other radiation producing machines must be submitted to the RSO for review. If the proposal is not authorized on the School's radioactive material license, an amendment to the Mines license is necessary and the proposal must be submitted to the CDPHE for review and approval prior to implementation. This can take time.

The descriptions of facilities and equipment, the training and experience of the user, and the operating or handling procedures shall be provided in sufficient detail to permit the RSO and the CDPHE to evaluate the safety of the proposed use.

5.2. Information Required for Use of Licensed Materials

The following information is required when submitting a new proposal. A form is available from the RSO to assist in this process.

5.2.1. Introduction

State the purpose of using the material, the overall objectives of the research and the benefits to the scientific community and the School.

5.2.2. Radiation Sources

Describe the radiation source(s) including physical and chemical forms and hazards. Provide, in clear laymen's terms, the procedures to indicate all intended uses of the source(s).

5.2.3. Personnel

Provide the names of all individuals working with radioactive materials. Each user will be classified depending on their level of use and will be required to complete all training commensurate with their classification before any use is permitted.

5.2.4. Facilities

List the buildings, rooms, facilities and equipment that will be used during the project. Attach detailed maps of the laboratories that show work, storage, and wipe test locations. Wipe test areas should include floors, doors, countertops,

and designated radiation work areas. The RSO will evaluate the submittal and determine if the locations are adequate. Authorized Users using sealed sources may be required to have leak tests performed in accordance with State regulations. The RSO can make this determination and coordinate periodic leak testing. Authorized Users using ***only*** sealed sources are not required to submit wipe test locations for their laboratory.

5.2.5. Security

Discuss security measure in place to prevent unauthorized access to radioactive sources and waste considering shared room accessibility and other related issues.

5.2.6. Postings

Sources of ionizing radiation and the areas where they are located are required to have radiation warnings signs. The RSO will advise you as to what signage is appropriate. The RSO follows the regulatory guidance as issued by the State of Colorado Radiation Control regulations.

Discuss postings for doors, work areas, storage locations and instruments. Doors are required to have emergency numbers posted on the outside. Work areas should be posted with the appropriate labeling. Instruments used to count samples (LSC, gamma counters, etc.) need to be adequately posted.

5.2.7. Procedures and Safety

Provide methods, procedures, rules, etc. that will ensure radiation safety during the project. Procedures should address safety precautions during specific steps of the process that may generate increased doses to individuals, possible airborne release, and procedures to reduce waste and new procedures that have been developed to address safety and/or waste production. Detailed procedures are not necessarily required and should be discussed with the RSO.

Demonstrate appropriate laboratory safety measures. This should include the use of lab coats, types of gloves, complete coverage of legs and feet, personnel monitoring, eating and drinking in the laboratory, applying cosmetics in the laboratory and other precautions where appropriate.

5.2.8. Dose Estimates

Clearly show the calculations for the expected internal doses for all users. Demonstrate that normal working time doses do not exceed occupational dose limits. Calculate worst-case dose scenarios and inform individuals working in the laboratory. The RSO can help you determine this information.

5.2.9. Waste Disposal Plan

Discuss the quantity of waste that will be generated including **mixed** and **biohazardous** waste. List methods used to minimize waste generation. Describe the waste containers that will be used.

5.2.10. Instrumentation and Surveys

List in detail the radiation safety equipment that will be used during the project. Indicate if it is borrowed or shared. The RSO will evaluate if it is appropriate for the type of radiation material being used. A liquid scintillation counter must be used for tritium detection. Include the frequency of wipe test that will be performed.

5.3. License Amendment Proposals

Any desired revisions to an authorization should be discussed with the RSO. If the RSO determines that the proposed revision does not involve any change from the initial safety evaluation, and is within the intent of the initial authorization, the revision may be approved by the RSO. If the proposed revision involves significant changes in sources or conditions of use from those specified initially, the proposal must be submitted to the CDPHE for authorization.

Upon request by qualified faculty members, the RSO will prepare requests for amendments to the School's radioactive materials license. Amendments are needed whenever radioactive material is to be added or deleted from the license, authorized users are added or deleted, or the purpose, location or procedures for handling licensed radioactive materials are changed.

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6. ACQUISITION AND USE OF RADIOACTIVE MATERIALS

6.1. Purchasing

All purchases of radioactive materials must be approved be the Radiation Safety Officer to ensure that new sources comply with license requirements. If a license amendment is needed to obtain the desired product, a delay should be expected. All radioactive materials must be procured through the Chemical Storage and Distribution Facility (CSDF) in Coolbaugh Hall.

6.2. Receiving

All deliveries of radioactive materials must be made at the CSDF and checked for contamination prior to being delivered to the laboratory. Upon receipt, the RSO will perform a package survey, assign an inventory tracking number, and enter related information into a database. Following completion of these tasks, the source may be released to the Authorized user.

6.2.1. Delivery to Campus and Receipt Survey

An RH inventory number is assigned by the RSO. Users should carefully note this number as it tracks the source from arrival to disposal.

6.2.2. Contaminated or Leaking Packages

Any damage to or leaking of a package should be reported immediately to the RSO. Measures should be taken to prevent to spread of contamination and determine the extent of possible contamination. The RSO will see that appropriate parties are notified.

6.3. Shipping and Transfers

All shipping and transfers of radioactive material must be performed by qualified personnel trained in US Department of Transportation (DOT) regulations. Therefore all shipping and transfer of radioactive materials are performed by the Radiation Safety Office, or someone else trained in the DOT regulations. Simply contact the RSO if you need to ship/transfer radioactive material.

X-ray machines may be shipped or transferred by the user, but the RSO must be notified. These machines are registered with the State of Colorado and Mines is obligated to notify the State when the machines are moved. The RSO performs this task.

6.4. Storage and Security

Parts 4.25 and 4.26 of the CDPHE *Rules and Regulations Pertaining to Radiation Control* state the following regarding storage and control of licensed or registered sources:

1. The licensee shall secure from unauthorized removal or access licensed or registered sources of radiation that are stored in unrestricted area.
2. The licensee shall control and maintain constant surveillance of licensed or registered radioactive material that is in an unrestricted area and that is not in storage or in a patient.
3. The registrant shall maintain control of radiation machines that are in an unrestricted area and that are not in storage.

In other words, keep it locked up or keep it attended.

7. General Radioisotope Laboratory Safety Procedures

The following procedures cover the safe handling of radioisotopes in unsealed or dispersible forms.

7.1.1. Responsibilities

Each person who works with unsealed or dispersible radioactive materials is responsible for:

1. Knowing the basic properties of the radioactive materials to be used, e.g. the half-life of the nuclide(s), the type(s) of radiation emitted, and any shielding that may be required.
2. Following the instructions or procedures provided by the Authorized User and RSO.
3. Surveying of hands, gloves, clothing, equipment and work areas frequently during experiments involving more than 1 ALI of unsealed sources and **before leaving the laboratory.** An ALI is an activity quantity of radioactive material that would give a person the yearly dose limit if intake. The RSO can provide users detailed information on ALIs.
4. Recording the results of all radiation surveys and screening bioassays promptly, completely and accurately.
5. Always use gloves when handling unsealed radioactive materials. Wear protective clothing (e.g. lab coats, eye protection, etc.) in the laboratory. Open-toed shoes and short pants are not permitted.
6. Clean up minor spills immediately. For larger spills, follow emergency procedures.
7. The lab door should be locked anytime there is no one physically in the lab. Radioactive materials and waste will be secured in locked containers/cabinets if laboratory access is not restricted to unauthorized personnel.
8. The concepts of time, distance and shielding are used to minimize radiation exposure. To prevent internal exposure of radioactive material in the body, high standards of cleanliness and good housekeeping must be maintained in all laboratories where radioactive materials are present.
9. Wash hands and arms thoroughly before handling any object that goes into the mouth, nose or eyes (e.g. cigarettes, cosmetics, foods, contact lenses, etc.). Smoking, eating, drinking and the application of cosmetics in radioisotope laboratories is **not allowed**. Never pipette by mouth.
10. For new procedures and new personnel, one or more trial runs with nonradioactive materials are recommended to test the effectiveness of procedures, training, and equipment.
11. Use appropriate shielding when warranted. Do not use lead shielding for high-energy beta emitters.

7.1.2. Posting Radioisotope Laboratories

Each room containing radioisotopes should be labeled with a “CAUTION RADIOACTIVE MATERIALS” label in accordance with regulations. Another label should indicate the name and phone numbers of the Authorized user and or another individual designated as an emergency contact. Other postings such as “Caution Radiation Area” may be necessary and will be determined by the RSO.

A “NOTICE TO WORKERS”, provided by the Colorado Department of Public Health and Environment and available from the RSO, shall be posted where anyone entering the laboratory can see it.

7.1.3. Radiation Survey Instruments

The Authorized User shall ensure that instruments used for determining exposure rates or for direct detection of contamination are capable of responding appropriately to the kinds of radiation anticipated and have been calibrated within the past year. The RSO is able to offer assistance with selecting appropriate instrumentation. Access to a backup meter is highly recommended.

The RSO maintains an instrument database and is responsible to assist the AU in assuring that instruments are calibrated annually.

In laboratories where **only** tritium is used, direct surveys are not appropriate and all contamination surveys shall be made by means of wipe tests run on a liquid scintillation counter or other instrument capable of detecting tritium.

7.1.4. External Exposure Control

Careful planning of work, good handling techniques and thorough monitoring are all necessary to minimize exposure. Adequate shielding and distance from sources are also important factors in reducing exposure. Shielding should be designed to protect in any direction where the radiation can impact a human. This can be verified by measuring exposure rates above, below, behind, and at the sides of storage locations.

An exposure rate survey should be performed when sources of penetrating radiation are first acquired, when the quantities of these nuclides are increased and when physical arrangements for handling or storage are modified. Additional surveys should be performed occasionally to assure that inadvertent changes in exposure rates have not occurred. If the user does not have a survey instrument that is appropriate for exposure rate measurements, the RSO is able to perform the survey.

7.1.5. Prevention of Intake of Radioactive Materials

Ingestion of radioactivity must be prevented by **avoiding mouth contact** with any items handled in a radioisotope laboratory, by **prohibiting eating, drinking, make-up application and smoking** in radionuclide handling areas and by careful attention to personal hygiene.

Gloves, lab coats, or other protective clothing that completely covers the legs and feet, should be available and worn to prevent contamination of skin and personal clothing. Lab coats and gloves should not be worn outside of the radionuclide handling area. Sandals or other open toed shoes and shorts or short skirts are not acceptable for work with radionuclides.

Work, storage and waste areas should be provided with secondary containers and covered with absorbent paper when permits. Plastic trays are suitable for use as secondary containers if they have raised edges. The protective covering should be replaced when it becomes excessively dirty or contaminated.

Inhalation of radioactive materials must be prevented by performing all operations that release gases, vapors or dusts in approved fume hoods. The sash of a fume hood is intended to serve as a shield to protect the face from splatters, as well as to control airflow. To provide proper protection, the hood must be free of major obstructions to the flow of air and the sash should be set at the height that was labeled when the airflow rate was measured. The average face velocity should be in the range of 80 to 150 fpm. If the desired velocity cannot be maintained, the user must make arrangements for repairs or modifications.

In emergency situations, filtered or supplied air respirators are used to prevent inhalation of contaminants. Whenever the probability of airborne contamination is significant, the RSO should be notified and air sampling may be required.

7.2. Laboratory Record Keeping

All radioisotope inventory forms must be kept up to date and should be forwarded to the RSO as soon as the inventory item is completely disposed. The results of radiation surveys are to be recorded and retained for a minimum of three years. They are to be made available for review and evaluation by the RSO and the appropriate licensing agency. Personal surveys should indicate the name of the individual surveyed and, if any contamination was found, the location on the body or on the clothing. Regulations require that contamination survey results be recorded in disintegrations per minute (DPM).

8. CONTROL AND MONITORING OF RADIATION EXPOSURES

8.1. Radioactive Materials and X-rays

Radionuclide sources that emit penetrating radiation should be stored and handled with appropriate shielding whenever physically possible. For gamma and X-rays, high-density materials, e.g. lead, provide the most effective shielding. For energetic beta-particle emitters, i.e. ^{32}P, low atomic number materials, e.g. plastics, should be used as primary shielding. Radioactive materials should be stored in approved and labeled containers and locations so that unauthorized individuals do not have access.

Radiation exposure rates decrease rapidly with distance from the source. Radionuclide sources that emit penetrating radiation should be stored away from regular work areas. They should also be handled only when necessary and preferably with tongs or forceps to eliminate direct contact and to increase the distance between the source and user.

8.2. Personnel Monitoring

A radiation dosimeter does not provide protection; it merely verifies, after the fact, the adequacy of the radiation control program within the laboratory or facility. The primary purposes for performing the individual monitoring are:

1. To monitor the individual's radiation environment,
2. To promote safe work habits,
3. To document radiation accidents,
4. To satisfy medical and legal requirements necessary to protect the employee and the employer, and
5. To comply with pertinent federal, state, and local regulations.

Radiation Users who are exposed to penetrating radiation from external sources, and who are unlikely to receive more than 10% of any external occupational dose limit, are not required to wear personal badges. All radiation users who have to potential to receive more than 10% of any external occupational dose limit are required to wear a personal badge. Users subject to general whole-body exposures are issued "body badges", which are to be worn on the front of the torso at all times when working with radiation sources, or on the outside of the collar if a lead apron is worn. The front of the badge should be oriented towards the source of radiation.

Extremity (ring) badges are required when significant quantities of radioisotopes that emit penetrating radiation must be routinely handled directly, or when the hands or fingers could be exposed to a high intensity source such as an X-ray diffraction unit or gamma beam.

Individuals who have been issued one or more dosimeters for any reason are required to wear them at all times when they are working in the presence of any radiation source. When not being worn, badges are required to be stored away from heat and radiation sources and **not to be taken home or to non-Mines facilities**. Wearing someone else's dosimeter, tampering or experimenting with personal dosimeters will be considered a serious violation of the School's Radiation Protection Program.

All dosimeters are changed on a quarterly basis and must be exchanged in a timely manner. Badges are grouped by department and a “control” or background badge is sent by the distributor for each group. This control is used to determine the normal background dose and the approximate dose to the badges during shipping. Late returned badges cannot accompany their respective control badges and therefore cannot have the dose associated with background subtracted from the actual dose received by the wearer. Thus, an inaccurate, elevated dose may be reported for late badges.

8.2.1. Prior Occupational Doses

All new participants of the School’s dosimetry program who have been monitored at another institution or organization must complete a “REQUEST FOR RADIATION EXPOSURE HISTORY AND/OR TRAINING VERIFICATION” form. A separate form is required for each institution or organization where dose records are on file. Once completed and signed by the individual, the RSO will send the form and process any replies to determine the occupational radiation dose received during the current year and compile records of lifetime dose history.

8.2.2. Investigation Action Levels and Reporting Events

The RSO has established investigation levels of radiation dose received during a monitoring period. Whenever the dose recorded by a badge exceeds the investigation level, the RSO will investigate the cause of the dose and offer steps that might be taken to prevent recurrence.

Reporting Levels and Deadlines to the State of Colorado			
	(effective dose equivalent in rem)		
	Immediately	24 Hours	30 Days
Total Body:	25 rem/event	5 rem/event	5 rem/year
Eye:	75 rem/event	15 rem/event	15 rem/year
Skin or Extremities:	250 rem/event	50 rem/event	50 rem/year
Any Other Single Organ:	Not applicable	Not applicable	50 rem/year
30 days – Average ^{3}H urine concentration >28 μCi/L average over a calendar quarter 7 days – Any single urinalysis which discloses a concentration of greater than 50 μCi/L			

Colorado School of Mines Investigation Levels			
	(effective dose equivalent in rem)		
	External Dose to Body	External Dose to Extremities	Intake by any route
Fetal Badges:	50 mrem/month	N/A	0.5 ALI
All Others:	150 mrem/month	500 mrem/month	0.5 ALI

8.2.3. Annual Reporting

Annual occupational doses are calculated for all program participants. Records of total received doses are entered and reported on forms prescribed for that purpose by the CDPHE. All dosimetry program participants are informed of their calculated annual doses each year.

8.3. Occupational Dose Limits

Radiation Dose Limits **Application**	**Dose Limit** (mrem/yr)
Occupational Exposure Limits	
Effective dose limit for stochastic effects	5,000
Effective dose limit for deterministic effects	
Lens of eye	15,000
Extremities	50,000
Whole Body	50,000
Effective dose limit for embryo or fetus (gestation period)	500
Occupational Exposures of Minors (under age 18)	10% of adult limits
Exposure of any member of the general public (CDPHE RH 4.15.2.2.2)	50 (or 2 mrem in any 1 hr)

8.4. Public Dose Limits

Doses to the public from licensed sources and registered radiation producing equipment on the School's campus are governed by CDPHE regulations RH 4.14 and 4.15. In

general, doses to the members of the public from unsealed sources are controlled through the use of procedures and equipment that prevent the release of radioactive material from laboratories. Measures to avoid internal doses to the public are built into the design of experiments which require the use of licensed radioactive material.

It is noted that RH 4.15.2.2.2 specifies the dose to the public from external sources cannot exceed 0.002 rem in one hour and cannot exceed 0.05 * rem in a year. In order to ensure compliance with these standards, exposure rates in public places on the Mines campus will be limited to not more than 2 mrem in any one hour. The RSO also incorporates the probable time of public exposure into the estimates of public exposure and dose.

Experimental design and waste disposal procedures shall ensure that gaseous or liquid effluents do not exceed the concentrations limits prescribed in Table II, Appendix B of Part 4 of the State Rules and Regulations Pertaining to Radiation Control.

(* note that this is half the dose allowed by other regulatory bodies, e.g. the NRC 10CFR1301, so be mindful of this if you have worked under other radiation regulations.)

8.5. Bioassays

Although emphasis of the radiation protection program is primarily focused on the prevention of unnecessary exposures, measurement and evaluation of exposures may also be required. Bioassays are an important tool for evaluating actual or suspected internal exposure to radioactive material.

Users of radioactive iodine ($^{125}I/^{131}I$) in quantities >50 mCi at any one time or unvented laboratory operations involving >10 mCi require thyroid bioassays. Tritium bioassays are required when a person utilizes >100 mCi of tritium in a non-contained form, other than metallic foil.

9. LABORATORY SAFETY EVALUATIONS AND SURVEYS

9.1. Sealed Source Leak Tests

Sealed sources of radioactive material shall be tested for leakage at regular intervals to verify the integrity of the source containment and, in the unlikely event of failure, to detect the escape of radioactive material before serious contamination of facilities, equipment or personnel occurs. The frequency of leak tests, and the sensitivity of detection of escaping radioactive material, shall comply with the regulations or license conditions specified by the CDPHE. Leak tests shall be performed only by qualified individuals using procedures approved by the RSO. Records of sealed source leak tests shall be maintained by the RSO.

9.1.1. Leak Test Frequency

Each sealed source containing radioactive material other than tritium, with a half-life greater than 30 days, and in any form other than gas, shall be tested for leakage or contamination prior to initial use and at intervals not to exceed 6 months, with the following exceptions:

1. Any sealed source containing 100 μCi or less of beta and/or gamma emitting material is exempt from leak testing.

2. Any sealed source containing 10 μCi or less of alpha emitting material is exempt from leak testing.

3. Except for alpha sources, an unused sealed source in storage need not be tested; however it must be test upon removal from storage.

4. Any sealed source for which a different frequency for leak testing is specified as a license condition shall be tested in accordance with that condition.

5. Some generally licensed sources that are not included in the above categories may also be exempt from leak testing. This exemption must be verified on a case-by-case basis.

9.1.2. Collection, Analysis and Detection Limits

For most sealed sources, leak tests must be capable of detecting 0.005 μCi of removable activity on the outside of the source capsule housing. Radioactivity leaking from a sealed source can be detected by wiping the source capsule or housing with an appropriate wipe media which is then measured for removable activity. If the source activity is in the range of mCi, the source capsule should be wiped directly, if possible. For sources in the multi-curie range of activity, the wipes should be made on the accessible surface of the source housing.

Wipes may be sent to an outside lab licensed to perform leak-test analysis.

9.1.3. Leaking Source Procedures

If the removed activity exceeds 0.005 μCi, the source shall be removed from service and assumed to be defective until proven otherwise. **A source that shows evidence of leaking must also be reported to the CDPHE within 5 days.**

9.2. Contamination Surveys

Surveys for contamination on the hands and clothing must be performed immediately after working with unsealed sources to allow detection and removal before the material enters the body. Application of the ALARA principle dictates that no removable contamination shall be tolerated indefinitely. Whenever contamination is detected, it must be removed promptly to prevent its spread and the possible exposure of other individuals. Any radioactive material on the skin must be removed promptly by normal washing. See the Radiation Protection Program, Emergency Procedures section for instructions.

A thorough survey of the entire working areas must be **performed and recorded by the user** in each radioisotope laboratory on a regular basis according to the level of use. The required frequency of performing routine laboratory surveys is determined by the nature and quantities of radionuclides and the conditions of use in addition to any specific license conditions.

9.2.1. Direct Surveys and Wipe Tests

Measurements of contamination by direct detection should be made of representative surfaces. An audible instrument response should be used during direct surveys because of the faster and more sensitive response and because it eliminates the need to watch the meter constantly.

To determine quantities of removable contamination, or to survey areas that are inaccessible to a survey instrument, wipe tests shall be taken. An area of 100 to 300 cm^2 should be wiped with absorbent paper for each test. If energetic beta emitters are involved, the activity on the filter may be measured directly with a thin-window GM survey meter in emergencies, but the wipe filter should be analyzed with a liquid scintillation counter or other appropriate counters for quantitative results.

1. Unless the ***only*** nuclide used is tritium, a direct survey should be made with a portable instrument. For each portable survey instrument used, check the calibration date and the calibration factor. Note to subtract the background from the gross count results to get the net count results.

2. With the audible response turned on, move the detector slowly over all surfaces at one detector width per second that might be contaminated, holding the detector 1-2 cm from the surface. Record the highest net response for each object or location surveyed.

3. At locations with positive survey results, first ascertain whether the reading could be penetrating radiation coming through the surface, rather than from surface contamination.

4. At locations with positive results from contamination, or surfaces that are not accessible for a direct measurement, use a dry filter paper to take a wipe of a 100 to 300 cm^2 area.

5. Using the portable survey instrument in a low background location, make a direct measurement of the contamination on the filter paper. Record the results according to the directions on the survey form. Count the wipe in a liquid scintillation counter and print out the results and to attach to the wipe test form.

6. If contamination from low-energy beta emitters, e.g. ^{14}C, ^{35}S, wipes should collected and counted in a liquid scintillation counter. If only tritium is used, take wipe samples of all objects and surfaces that are normally touched or readily accessible

9.2.2 RSO Surveys

The Radiation Safety Office shall perform laboratory surveys in accordance with Lab Safety Procedures.

9.3. Airborne Activity

Monitoring of radioactivity in air is important because inhalation is a common route of intake of such material by workers. Air monitoring is usually done in facilities handling large amounts of radioactive material or facilities using volatile material. On a laboratory scale, the common procedures of good housekeeping will prevent air contamination and this is commonly confirmed through negative results of surface contamination monitoring. Air monitoring may be performed per special request.

10. Radioactive Waste Management

10.1. Waste Collection and Packaging

Radioactive wastes collected by EHS will be stored, packaged, shipped and disposed of in accordance with all pertinent state and federal regulations.

10.1.1. Empty Containers

If an empty radioisotope container is not contaminated, it should be disposed of as non-radioactive trash. **All radiation symbols and warning labels must be obliterated before an empty container is discarded.** Discarded lead containers cannot be disposed of through the regular waste and therefore must be kept separate.

10.1.2. Uncontaminated Dry Wastes

Whenever possible, potentially contaminated waste materials, e.g. gloves, absorbent paper etc., should be surveyed before disposal. **If the absence of radioactive contamination can be verified, remove or obliterate all radiation labels and discard the material as ordinary trash.**

Since tritium cannot be detected by direct survey, materials potentially contaminated with tritium must be surveyed by wipe tests or assumed to be contaminated. For other low-energy beta emitters, direct surveys are possible on directly accessible surfaces, but may miss contamination embedded in absorbent materials. For high-energy beta or gamma emitters, direct surveys with appropriate instruments can usually detect contamination even when embedded in absorbent material.

10.1.3. Compactable Dry Radioactive Wastes

Solid wastes containing no hazardous, toxic, or pyrophoric materials, no compressed gasses and no free liquids are collected and handled as compactable dry waste. EHS will provide appropriate, covered containers and plastic bag liners. Syringes, needles, pipettes, etc. must be placed in a “sharps” or other puncture proof container. Wastes containing ***only*** nuclides with half-lives of less than 100 days and no “RADIOACTIVE MATERIAL” labels shall be packaged separately for disposal by radioactive decay. As materials are added to a container, the RH number and required information should be recorded on the “REQUEST FOR RADIOACTIVE WASTE COLLECTION” form.

10.1.4. Liquid Waste Collection and Segregation

All radioactive liquid wastes are to be segregated and collected for disposal by EHS. Separate containers are provided for materials, which would be incompatible if placed in the same container, e.g. aqueous solutions and organic solvents, as well as for nuclides with different half-lives.

Liquid waste containers are to be non-breakable, e.g. plastic jugs or metal cans, capable of leak tight closure and are placed in secondary containment. Aqueous wastes must be neutralized to prevent violent chemical reactions when the wastes are transferred. Organic solvents and other hazardous materials must be clearly and completely identified

to permit safe handling. No solid objects are to be placed in any liquid waste container and the materials must be sufficiently fluid to be poured from the container.

Biologically active materials are to be deactivated or detoxified at the time they are placed in the waste container. A chlorine disinfectant (e.g. liquid bleach) should be added to putridable liquid wastes to prevent putrification; the quantity depending on the concentration of organic material in the waste. Care must be taken to prevent a reaction between the waste and the disinfectant.

Each addition to a liquid waste container from a single RH inventory item are required to be recorded on the "REQUEST FOR RADIOACTIVE WASTE COLLECTION" before the container will be accepted fro final disposal. The total activity of each RH inventory number shall be summed at the end of the form.

10.1.5. Liquid Scintillation Media and Vials

Users are required to use nonhazardous, nontoxic liquid scintillation media to the maximum extent that is compatible with research requirements. The use of flammable or otherwise hazardous liquid scintillation media must be justified in writing and approved before use.

Used vials are to be securely capped and segregated, according to the liquid scintillation medium and the radioisotopes they contain, and stored in plastic lined, 5 gallon pails provided by EHS. No other waste materials should be placed in waste containers containing vials.

10.1.6. Special Wastes

Any Radioactive wastes not included in the above categories, or exhibiting unusual hazards, or requiring precautions of any kind, are handled under special arrangements with the RSO. Whenever unusual wastes are anticipated, the user should contact the RSO to plan for disposal before the wastes are generated.

10.2. Labeling of Radioactive Wastes

All containers in which radioactive wastes are collected must be labeled "CAUTION – RADIOACTIVE MATERIAL" or "CAUTION – RADIOACTIVE WASTE". Containers in which radioactive wastes are stored or transported must be labeled with a "waste tag". The tag must be completed and attached to each container before it will be accepted for disposal.

11. RADIATION SAFETY PROGRAM MANAGEMENT

11.1. Recordkeeping and Forms

The RSO maintains the major files of radiation records for the School. Records of all individuals identified as radiation users are maintained indefinitely. The records for individual radiation users contain data on radiation safety training and experience, as well as on personal radiation monitoring and exposures.

Records of Authorized Users and general information pertaining to the personnel or activities of the entire group for whom the Authorized User is responsible, are maintained.

Personal data on individual radiation users are maintained in file folders under the Authorized User. These records are treated as confidential and shall be accessible only to those with an official need to know. Personal records shall not be released to other individuals or organizations without the written permission of the individual.

11.1.1. Current Inventory

The current inventory of radioactive materials possessed by the School is maintained by the RSO in a computer database that allows reporting of inventory by Authorized User, by license item, etc. Records of receipts, transfers and dispositions of radioactive materials, including surveys of incoming packages and transfers to waste containers, are maintained.

11.1.2. Training

All records of prior radiation safety training or training completed at the School are maintained. Dates of training are also entered into a training database on the computer.

11.1.3. Dosimetry

Summaries of radiation exposure monitoring and doses received shall be prepared for and provided to each radiation user annually. A summary of occupational doses and the investigations conducted to implement the ALARA program are reported in the annual audit.

11.1.4. Surveys

Surveys of radioisotope laboratories, and other areas where sources are used, are maintained. Routine laboratory surveys conducted by laboratory personnel are maintained in the laboratory and are available for review.

11.1.5. Disposal

Records of shipments of radioactive wastes to waste brokers or to disposal sites are maintained in a separate waste shipment file.

11.2. Portable Radiation Survey Instrument Calibration

The current inventory of portable radiation survey instruments and their calibration dates are kept in a computer database that allows for reporting of instruments coming due for calibration. Hard copies of calibration certificate records are also kept on file.

11.3. Annual ALARA Review

The RSO is responsible for conducting an annual ALARA review, to identify and correct deficiencies in radiation protection program content and application. The following is a list of program review topics.

1. Program Management
    a. Radiation Safety Officer, functions and performance
    b. ALARA policy and implementation
    c. Record management: organization, security and retention
2. User Authorizations
    a. Non-medical use of radioisotopes
    b. Radiation generating machines
3. Emergency Planning
4. Training
    a. Normally exposed radiation users, including radioisotope and machine users
    b. Emergency personnel, e.g. police, firefighters, security, etc.
    c. Ancillary exposed personnel, e.g. nurses, facilities maintenance, custodians, etc.
5. Radioactive Materials Control
    a. Procurement, package receiving, inventory records, disposal records
    b. Waste handling, packaging and shipping, effluent and environmental releases.
6. Personnel Dosimetry
    a. External dosimetry
    b. Internal dosimetry
7. Radiation Exposure Control, Surveillance and Monitoring
    a. Radioisotope lab surveys
    b. Radiation generating devices
    c. Sealed source leak tests
8. Instrument Calibrations
9. Waste Management

12. Pregnant Workers' Declaration and Risks

12.1. Rules and Procedures

It is the choice of the individual to declare pregnancy. To voluntarily declare pregnancy, an individual must provide her name, a declaration that she is pregnant, the estimated date of conception (only month and year are required) and the date the letter was given to the RSO. The individual is not required to provide medical proof of pregnancy, but the declaration must be in writing. The lower dose limits established by the State apply only when the voluntary written declaration is received by the RSO. The lower dose limits apply to individuals until the RSO knows the individual has given birth, the RSO has been informed, in writing, that the individual is no longer pregnant, or the individual has informed the RSO she no longer wishes to be considered pregnant.

If an individual has declared herself pregnant, the individual should promptly inform the RSO in writing that she is no longer pregnant (either by birth or other situation). The individual may revoke the voluntary declaration of pregnancy at any time, for any reason.

12.2. Potential Health Risks

The purpose of the lower limit is to protect the unborn child. Scientific advisory groups recommend a lower limit because of the sensitivity of the embryo/fetus to radiation. Possible effects include deficiencies in the child's development, especially the child's neurological development and an increase in the likelihood of cancer.

12.3. Declaration Procedures

Once a declaration of pregnancy has been received by the RSO, the whole body committed effective dose limit will decrease from 5 rem in one year for a radiation worker to 0.5 rem during the 9-month pregnancy. The voluntarily declared pregnant worker will also be limited to no more than a whole body committed effective dose limit of 50 mrem in any one month during the 9-month pregnancy. Substantial variation above a uniform monthly dose rate will be avoided, if possible, so that the dose received does not occur during a particular time of the pregnancy. If by the time the individual voluntarily declares pregnancy, the dose equivalent to the embryo/fetus is found to have exceeded 0.45 rem, the additional dose equivalent to the embryo/fetus shall not exceed 0.05 rem during the remainder of the pregnancy. (CDPHE 4.13)

13. Radiation Producing Equipment

13.1. Rules and Regulations

All operable X-ray generating machines used at Mines facilities shall be authorized by the Radiation Safety Officer and shall be registered with the Colorado Department of Public Health and Environment. The RSO shall be notified of purchasing, moving, transferring, disposing, or lost/stolen of any X-ray machine.

The Authorized User for each analytical X-ray machine shall assure that detailed operating procedures are available and that each operator has received appropriate training that has been documented and understands and follows the correct procedures. **These machines will not be for human use of any kind.**

13.2. Operating Requirements

Each person who will operate or maintain analytical X-ray equipment shall **first** receive appropriate instruction that is documented and demonstrate competence on operation of the X-ray machine.

Written operating procedures covering both normal and emergency conditions shall be available to, and followed by, all users of analytical X-ray equipment. The operating procedures shall include detailed instructions for sample insertion and manipulation, equipment alignment, routine maintenance by the user and recording of data related to radiation safety.

No person shall bypass a safety device without the written authorization of the RSO. Individuals who expect to perform maintenance

13.3. Surveys/Exposure Monitoring

The RSO will survey the radiation exposure rates in accessible areas near an analytical X-ray machine upon installation and at least once a year. **The Authorized User shall request or perform and record**, a radiation survey:

1. following any change in the arrangement, number or types of components,

2. following any maintenance requiring disassembly or removal of a component,

3. during any maintenance or alignment procedure that requires the presence of a primary X-ray beam when a component is disassembled or removed,

4. any time a visual inspection reveals an abnormal condition, or

5. whenever personal monitoring devices show a significant increase over the previous monitoring period.

Any suspected exposure to the primary beam of an analytical X-ray machine shall be reported promptly to the RSO.