COLORADO SCHOOL OF MINES

RADIATION PROTECTION PROGRAM

Last Revision: December 1997

1/84

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LIST OF ATTACHMENTS

1 RADIATION SAFETY OFFICER (R.S.O.) The Director of Environmental Health and Safety is the Radiation Safety Officer

2 RADIATION SAFETY SUBCOMMITTEE· The subcommittee is a component of the University Safety Committee and is composed of the Vice-President for Academic Affairs (or his/her designee), two faculty members and the R S O The subcommittee meets at least semiannually Attachment 1 is an excerpt from the Faculty Handbook which describes the organization of the Radiation Safety Subcommittee

3 POLICIES AND PROCEDURES CONCERNING RADIATION SAFETY TRAINING AND AUTHORIZATION TO POSSESS RADIOACTIVE MATERIALS OR OPERATE RADIATION PRODUCING EQUIPMENT

A General

Colorado School of Mines (CSM) faculty and staff utilize a variety of sealed and unsealed radioisotopes and radiation producing equipment Use of such equipment and material is regulated by the Colorado Department of Public Health and Environment (CDPHE), Laboratory and Radiation Services Division The Division has published detailed written regulations A copy of those regulations is kept in the CSM Environmental Health and Safety (EHS) office in Chauvenet Hall CDPHE has the legal authority to enforce these regulations on the CSM campus

CDPHE authorizes the presence of radioactive materials on the campus by issuing a license to the School Each radioactive source is listed in the license The individual faculty member who is responsible for each source is also listed The license contains additional requirements for training, waste disposal, leak testing, wipe testing, labeling and signage All faculty, staff and students who utilize radioisotopes or radiation producing equipment shall comply with applicable provisions in the School's radioactive materials license and in State Radiation Control regulations

B Classification of Users of Radioactive Materials and Operators of Radiation Producing Equipment

1 Operators of Radiation Producing Equipment Radiation producing equipment includes x-ray diffraction and fluorescence equipment and particle accelerators A qualified faculty member must be responsible for the use and maintenance of each item of radiation producing equipment When necessary, the Radiation Safety Committee renders binding judgment concerning the qualifications of faculty members to supervise the use of radiation producing equipment The supervising faculty member is responsible to provide safety training to staff members and students who are authorized to operate the equipment Only persons who are authorized and trained by the supervising faculty member are allowed to operate radiation producing equipment Upon request, the supervising faculty member shall notify the Radiation Safety Committee concerning the identity of persons who are authorized to utilize an item of radiation producing equipment Upon request, the supervising faculty member shall also provide documentation concerning the adequacy of safety training which has been provided to each equipment operator

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II Authorized Users of Radioactive Materials A qualified faculty member must be responsible for the use, storage, handling and disposal of each regulated radioactive source on the campus Qualified faculty members apply to the Radiation Safety Committee for authorization to possess radioactive materials The Radiation Safety Officer is the administrative point of contact for the Radiation Safety Committee in such matters Applicant faculty members may be required to provide documentation of training and experience which qualifies them to possess the desired source Authorized users must be specifically identified in the School's radioactive materials license The Radiation Safety Officer applies for amendments to the license for purposes of designating new authorized users, deletion of inactive users or to change the inventory of licensed sources on the campus The term "authorized user" applies to faculty members who are identified in the School's radioactive materials license as persons approved to possess regulated sources of radiation

Authorized users supervise staff members and students in handling radiation sources Authorized users designate supervised users and assign them to function in one of two subordinate user categories 1) directly supervised users and 2) independent supervised users. The authorized user provides personal supervision of directly supervised users at all times when these persons are handling radioactive materials Authorized users also promote directly supervised users into the independent supervised user category after the individual has completed a 10-hour Radiation Safety Training course (or equivalent)

III Directly Supervised Users These are persons who have not completed the 10-hour Radiation Safety Course (or equivalent) Directly supervised users may handle radioactive materials only if they are in the presence of, and under the direct personal supervision of the authorized user

IV Independent Supervised Users These are persons who have completed the 10-hour Radiation Safety Course (or equivalent) Independent supervised users may handle radioactive material under the general guidance and direction of the authorized user, however the authorized user need not be present to personally oversee the activities of the independent supervised user

C Radiation Safety Training

The Radiation Safety Officer will offer a 10-hour Radiation Safety Course each semester The course will be offered in five 2-hour modules The Radiation Safety Officer will widely advertise the availability of the course prior to each course offering There will be no charge for attending the course Completion of this course will qualify students and staff members to function as independent supervised users

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Topics to be covered during the course include

General Nuclide Nomenclature
Decay Processes/Growth of Radioactive Products
Mass/Energy Relationships
Radiation Dosimetry
    Absorption of Radiation by Matter
    Biological Effects
Radiation Detectors and Detector Calibration
Exposure Control Time, Distance, Shielding
Exposure Limits
    Members of the Public
    Radiation Workers
    Pregnant Women
    Persons Younger than 18 Years of Age
Laboratory Safety Procedures
    Handling of Radionuclides
    Sealed and Unsealed Sources
    Leak and Wipe Testing
    Shielding
    Labeling Signage
    Security
    Use of Dosimeters
    Inventory Control
    Waste Disposal

Attachment 2 contains lecture outlines and examples of quizzes and tests which may be administered

4 OCCUPATIONAL DOSE LIMITS AND DOSIMETRY PROGRAM New users of radioactive materials are informed of the requirement to participate in the institutional dosimetry program The memo in Attachment 3 is used to communicate this requirement The R S O will track the radiation exposure of users of radioactive materials and radiation producing equipment All users who have occupational exposure to radiation must participate in the badge dosimetry program The R S O reviews dosimetry reports and compares results with occupational exposure limits Excessive or anomalous readings are investigated

The R S O stays in contact with authorized users who utilize unsealed sources The potential for internal exposures are reviewed according to the circumstances of each specific use The R S O prescribes the use of protective measures such as ventilation, scrubbing of waste gases, etc In the event of a risk of internal exposure, the R S O prescribes air sampling or bioassays These data are utilized to calculate internal doses, utilizing methods described in Part 4 of the State Radiation Protection Regulations

Occupational doses are calculated each year for each user Records of dose calculations are entered on forms prescribed for this purpose by CDPHE Attachment 4 contains blank copies of these forms Participants in the institutional dosimetry program are informed of their calculated annual dose each year Attachment 5 is used to communicate this information to dosimetry program participants

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5 PUBLIC DOSE LIMITS Doses to the public from licensed sources and radiation producing equipment on the CSM campus are regulated by CDPHE Regulations, RH 4 15 and 4 14 The R S O performs an annual survey of public areas which are in proximity to sources of radiation on the campus The purpose of the survey is to check for compliance with the regulation Attachment 6 is the form which is used to record survey findings Radioactive materials storage areas are inspected for security during the annual survey

In general, storage and handling procedures for unsealed radioisotopes will eliminate the possibility of administering any significant internal dose to members of the public Measures to avoid internal doses to the public will be built into the design of experiments which require the acquisition of licensed radioactive material These measures will be described in proposed license amendments

Potential external exposures of members of the public to penetrating photon radiation will be evaluated utilizing a Ludlum Model 19 μ/R-meter The R S O will determine the closest point of public approach to locations where radioactive material is stored or handled The μR-meter will be used to measure the exposure rate at the closest point of approach It is noted that RH 4 15 2 2 2 specifies that dose to the public cannot exceed 002 rem (roughly equivalent to an exposure of 2 milliroentgen) in an hour and cannot exceed 05 rem (roughly equivalent to an exposure of 50 milliroentgen) in a year In order to ensure compliance with these standards, exposure rates in public places will be limited to not more than 2 millroentgen/hour at any time

The R S O will also factor the probable time of public exposure into estimates of public exposure and dose In general, the R S.O. will take action to ensure that School events and facilities do not encourage members of the public to linger for more than five minutes in public areas where radiation field strength exceeds background levels Enforcement of these time and exposure rate restrictions will ensure that doses to the public remain insignificant

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

6 LEAK/WIPE TESTING Sealed sources are subject to leak testing, quarterly or semiannually, as specified in the license Records are maintained on the form in Attachment 7

The authorized user of unsealed sources is responsible to perform wipe testing or instrument surveys (as appropriate) of radiation use areas in the laboratory on a monthly basis (minimum) The authorized user maintains a log book of wipe test and survey results in each laboratory Methods described in Chapter 11, Section 1 of The Health Physics and Radiological Health Handbook are used as guidelines for the conduct of leak and wiping testing and instrument surveys

7 INSPECTION/CERTIFICATION OF RADIATION PRODUCING EQUIPMENT (RPE) The R S O arranges for biennial inspection/certification of each item of RPE, including x-ray machines and particle accelerators The R S O maintains records RPE must not be operated until it has been inspected and certified Attachment 8 is a list of radiation producing equipment on the campus

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8. PREGNANT WOMEN/MINORS/NOTICE TO EMPLOYEES. The R S O reminds authorized users and RPE supervisors of the restrictive occupational dose limits for pregnant women and minors once a year in writing The correspondence also reminds authorized users and RPE supervisors to ensure that appropriate radiation safety warning signs and employee notices are posted Attachment 9 contains examples of the reminder notices

9 WASTE DISPOSAL The R S O must approve of any instance of disposal of radioactive material The Environmental Health and Safety office disposes of LLRW, NORM, source and II(e)2 material Incidental laboratory discharges of unsealed radioactive materials in air or sewers are monitored and approved by the R S O on a case-by-case basis The table in Appendix B, Part 4 of State Radiation Control Regulations is used as a guide to determine limits of releases to air and water All persons who generate radioactive waste must be trained and authorized Attachment 10 contains notifications of this requirement Attachment 11 is a form used to request disposal of regulated waste including radioactive waste Attachment 12 is a copy of a Hazardous Materials Emergency Information poster which is displayed in each campus laboratory The poster contains information concerning waste disposal and emergency procedures

10 EMERGENCY PROCEDURES The School maintains an Emergency Response Team which manages incidents involving radioactive materials Specific emergency response procedures are described in three internal documents entitled

D Hazardous Materials Response Plan
E Emergency Procedures and Contingency Plan
F Preparedness and Prevention Plan

Chapter 11, Section 5 in The Health Physics and Radiological Health Handbook is also used as a guide in the event of an emergency involving radioactive materials

11 ACQUISITION AND DELIVERY OF SOURCES All radioactive material must be procured through the Chemical Storage and Distribution Facility in Coolbaugh Hall All deliveries of radioactive material are first received at the central facility Safety personnel perform a survey of each new package Attachment 13 is the record form for package surveys Safety personnel also check the School's Radioactive Materials License to ensure that new sources comply with license requirements An inventory tracking sticker is then applied to primary containers/source holders The inventory tracking number and related information is then entered in a database When these operations are completed, the source is delivered to the authorized user

12 ANNUAL PROGRAM REVIEW The R S O accomplishes an annual review of the provisions in this Radiation Protection Program The review is documented in writing and kept as a permanent record

13 PROCEDURES FOR HANDLING RADIOACTIVE MINERAL SPECIMENS Attachment 14 prescribes methods for handling radioactive mineral specimens on the CSM campus

14 "ALARA" GOAL The goal of the CSM Radiation Protection Program is to keep public and occupational doses to radiation "As Low As Reasonably Achievable" (ALARA) on the CSM campus

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15 LICENSE AMENDMENTS Upon request by qualified faculty members the R S O 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, the purpose, location or procedures for handling licensed radioactive materials are changed The form and guideline in Attachment 15 are used in preparation of license amendments

16 RADIATION DETECTION INSTRUMENTS Survey instruments shall be calibrated at least annually Attachment 16 is an inventory of instruments on campus

ATTACHMENT 1

FACULTY HANDBOOK DESCRIPTION OF RADIATION SAFETY SUBCOMMITTEE

SAFETY COMMITTEE

FUNCTION To make recommendations to the Vice President for Business Affairs and the Vice President for Academic Affairs on matters relating to the safety of Colorado School of Mines personnel and facilities. **Problems relating to radioactive materials will be referred to a special Radiation Protection Subcommittee**

METHOD OF OPERATION Facilities and operational procedures will be inspected on a periodic basis to ensure that reasonable safety practices are being observed and that there is an understanding and adherence to safety regulations **The Radiation Protection Subcommittee will make recommendations regarding the handling of radioactive materials in compliance with the license issued to the Colorado School of Mines by the Division of Occupational and Radiological Health, Colorado Department of Public Health and Environment.**

MEMBERSHIP. Director of Environmental Health and Safety, Chair; President of CSM as Chief member (per Executive Order DO122 89); Director of Plant Facilities or a designated representative, Dean of Graduate Studies and Research; Director of Personnel/Affirmative Action, four members of the academic faculty approved by the Faculty Senate and appointed by the President; two members of the classified staff selected by the Classified Action Council and one member of the Radiation Protection Subcommittee. Faculty and classified staff appointments will be for two-year staggered terms **The members of the Radiation Protection Subcommittee will be the Radiation Safety Officer, Director of Environmental Health and Safety and the Vice President for Academic Affairs and Dean of Faculty**

12/17/97-Bob/Reports/Report79

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ATTACHMENT 2

RADIATION SAFETY COURSE MATERIALS

SUMMARY
10-HOUR RADIATION SAFETY COURSE

SESSION 1	HISTORY CURRENT PUBLIC POLICY ISSUES PHYSICS REVIEW
SESSION 2	MODES OF DECAY REACTIONS WHICH PRODUCE NEUTRONS NUCLEAR STABILITY ORIGINS OF RADIOACTIVE MATERIALS IN THE ENVIRONMENT ANNUAL DOSE TO THE PUBLIC
SESSION 3	DEFINITIONS ROENTGEN, RAD, REM RADIATION INTERACTIONS WITH MATTER PRINCIPLES OF RADIATION DETECTION
SESSION 4	RADIATION EXPOSURE AND DOSE BIOLOGICAL EFFECTS OF RADIATION RADIOLOGICAL HAZARDS - RECOGNITION AND CONTROL LABORATORY PROCEDURES EMERGENCY PROCEDURES
SESSION 5	REGULATORY DOSE LIMITS CSM'S RADIATION SAFETY PROGRAM WASTE DISPOSAL X-RAY MACHINES, ACCELERATOR CHARACTERISTICS OF COMMON RADIOISOTOPES

SESSION 1
RADIATION SAFETY COURSE
2 HOURS

1 HISTORY

- Discovery of Radiation and Radioactivity
- Early Uses of Radiation
- Radium Dial Painters
- Origin of the Profession of Health Physics

2 CURRENT PUBLIC POLICY ISSUES

- Waste Disposal
- Reactor Safety
- Fusion Energy
- Security of Weapons Grade U and Pu
- Proliferation of Nuclear Technology and Materials

3 PHYSICS REVIEW

- Define Radiation and Radioactivity
  - Particles and Waves
  - Electromagnetic Spectrum
  - Structure of the Atom
  - Periodic Table of the Elements
  - Ionizing and Non-Ionizing Radiation
- Mass Energy Relationships
  - $E = MC^2$
  - Binding Energy/Mass Defect in Fission/Fusion Reactions
  - Electron Volt/Equivalent Rest Mass of Particles
  - Atomic Mass Units
- Some Definitions
  - Half Life
  - Radioactivity - curie, becquerel

SESSION 2
RADIATION SAFETY COURSE
2 HOURS

1 MODES OF DECAY

- Alpha, Beta, Positron, Electron Capture, Internal Conversion
- Metastable States/Isomeric Transition
- Natural Decay Chains
- Chart of the Nuclides
- Isotopes/Isotones

2 REACTIONS WHICH PRODUCE NEUTRONS (PuBe)

3 NUCLEAR STABILITY

- Equilibrium
- Natural Decay Series

4 ORIGINS OF RADIOACTIVE MATERIALS IN THE ENVIRONMENT

- Natural
  - Decay Series
  - Natural Fission
  - Cosmic Rays
  - Radon
  - Environmental Radioactivity - Scientific Uses
- Manmade
  - Weapons Testing/Fission
  - Particle Accelerators
  - Neutron Activation
  - Reactor Accidents

5 ANNUAL DOSE TO THE PUBLIC

SESSION 3
RADIATION SAFETY COURSE
2 HOURS

1 MORE DEFINITIONS

- Roentgen
- Rad
- Exposure
- Dose
- REM

2 RADIATION INTERACTIONS WITH MATTER

- Charged Particle Interactions
  - Coulomb Forces
  - Stopping Power
  - Linear Energy Transfer
  - Ionization
  - Excitation
  - Bremsstralung
- Photon Interactions
  - Photoelectric Effect
  - Compton Scattering
  - Pair Production
- Elastic/Inelastic Collisions
- Neutron Interactions

3 PRINCIPLES OF RADIATION DETECTION

- Gas Filled Detectors
- Scintillation Detectors
- Solid State Detectors
- Dose Rate Meters
- Dosimeters
- Contamination Detection and Measurement
- Air Monitoring
- Neutron Detection
- Demonstrate Some Field and Laboratory Instruments

SESSION 4
RADIATION SAFETY COURSE
2 HOURS

1 RADIATION EXPOSURE AND DOSE

- Exposure (Roentgen)
- Absorbed Dose (RAD)
- Dose Equivalent (REM)
- Quality Factor
    - Relationship with LET
    - For Different Radiations
- Internal and External Dose

2 BIOLOGICAL EFFECTS OF RADIATION

- Dose-Response Relationship
- Cellular Effects
    - Variability of Cell Sensitivity
- Derivatives of Ionization of Water
    - Peroxides
    - Hydroxides
    - Free Radicals

3 RADIOLOGICAL HAZARDS - RECOGNITION AND CONTROL

- Acute Radiation Sickness
- Stochastic and Non-Stochastic Effects
- External Exposure
    - Penetrating (Gamma, X-Ray)
    - Non-Penetrating (Beta)
    - Inverse Square Rule
    - Rule of Thumb for Estimating Gamma Exposure Rate

      R/hr at 1 foot from a point source = 6 CEN

      Where C = Ci
      E = Mev
      N = Gamma Ray Yield
    - Rule of Thumb for Estimating Beta Dose Rate

      Rad/hr(at 1 ft) = 300 x (Ci)
- Shielding
    - Photon Attenuation

      Thickness/Density
      Half Value Layers
      Build Up Factor

- Beta Attenuation

    Bremsstralung

- Neutron Attenuation

- Time/Distance/Shielding
- Internal Dose

    - Routes of Entry
    - Airborne Radioactivity
    - Target Organs
    - Definitions

        Committed Dose Equivalent
        Committed Effective Dose Equivalent
        Derived Air Concentration
        Annual Limit of Intake

- Contamination Control
- Safe Laboratory Practices

    - ALARA
    - Personal Protective Equipment
    - Use of Dosimeters
    - Sealed Source Leak Testing
    - Lab Wipe Testing for Unsealed Sources
    - Ventilation
    - Labeling of Containers
    - Warning Signs on Doors/Refrigerators
    - Security

4 EMERGENCY PROCEDURES

SESSION 5
RADIATION SAFETY COURSE
2 HOURS

1 REGULATORY DOSE LIMITS

- Occupational Limits
  - Total Effective Dose Equivalent
  - Committed Dose Equivalent
  - Committed Effective Dose Equivalent
  - Deep Dose Equivalent
  - Shallow Dose Equivalent
  - Eye Dose
  - Shallow Dose Equivalent, Maximally Exposed Organ
- Occupational Limits for Pregnant Women and Minors
- Cumulative Occupational Dose History
- Annual Occupational Dose Calculations
- Public Dose Limits

2 CSM'S RADIATION SAFETY PROGRAM

- Radioactive Materials License
  - License Amendments
- User Classification
- Procurement of Radioactive Materials
- Tracking of Primary and Secondary Containers

3 WASTE DISPOSAL

- Releases to the Environment - Limits
- Waste Disposal Procedures
- Use of Aqueous Liquid Scintillation Cocktail

4 X-RAY MACHINES, ACCELERATOR

5 CHARACTERISTICS OF COMMON RADIO ISOTOPES

- Ce-137, H-3, C-14, Tc-99, Th, U, Co-57/60, P-32, I-130/125, Ra-226, Rn-222, Ni-63, S-35

RADIATION SAFETY COURSE
PROBLEM SHEET #1 — RADIOACTIVITY

Given We locate a container of PCP in alcohol which contains an unknown amount of C14 We put 1 gram of the solution in a beta counter and detect 9 25 X 10^6 disintegrations per second of C14 beta radiation

1 Question What is the specific activity of C14 in the solution in units of becquerels? In units of curies?

Given We weigh the PCP alcohol solution and find its weight to be 25 grams

2 Question What is the total activity of C14 which is present in the solution?

Given The half life of C14 is 5730 years

3 Question What is the decay constant for C14?

4 Question What is the mass in grams of C14 which is present in the solution if the total C14 activity is 6 25 mCi (Hint — use the specific activity equation on Page 6 of the Physics review handout)

5 Question How many atoms of C14 are present in the solution?

6 Question The C14 in the solution was created in a reactor by the process of neutron activation in 1982 The newly created C14 was then immediately compounded with PCP and added to the alcohol What was the activity of C14 in the solution when it was first created?

7 Question Your studies are going slowly and you figure that you won't complete your experiments until the year 2010 How many atoms of C14 will remain in solution then?

8 Question What is the decay product (daughter) of C14? How many atoms of the daughter will be present in the solution in the year 2010?

RADIATION SAFETY COURSE
PROBLEM SHEET #2 — MODES OF DECAY

1 If uranium (Z = 92) decays by alpha emission, what is its daughter element?

2 If U-238 decays by alpha emission, what is its daughter isotope?

3 If carbon decays by beta emission, what is its daughter element?

4 If C-14 decays by beta emission, what is its daughter isotope?

5 If Ce-134 decays by electron capture, what is its daughter?

6 If Rh-95 decays by positron emission, what is its daughter?

7 If Cs-137 is a pure beta emitter, how can its decay produce gamma rays?

8 If $Tc\text{-}99^{M}$ produces a gamma photon, how is the $Tc\text{-}99^{M}$ changed?

9 If Rn-222 decays by alpha emission, what is its daughter?

10 If Bi-210 decays by beta emission, what is its daughter?

11 If Cs-125 decays by positron emission, what is its daughter?

12 If Cs-125 decays by electron capture, what is its daughter?

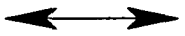
13 Is it possible for Cs-125 to decay to Xe-125 by positron emission or electron capture?

RADIATION SAFETY COURSE
PROGRESS QUIZ 1

1) The words "radiation" and "radioactivity" mean the same thing and can be used interchangeably True/False

2) Alpha and beta radiation are strictly "electromagnetic" in nature True/False

3) Match the following



a) Beta Radiation	a) Helium nucleus with charge of plus 2
b) X-rays	b) Electromagnetic radiation produced by orbital electrons
c) Ionizing Radiation	c) Energetic electrons
d) Alpha Radiation	d) Electromagnetic radiation produced within a nucleus
e) Non-ionizing Radiation	e) Heat, visible light, microwaves
f) Neutrons	f) A particle with zero charge
g) Gamma Rays	g) May take the form of waves or particles which are sufficiently energetic to cause ejection of orbital electrons from incident atoms

4) A gram of pure Carbon 14 is mixed with 2 grams of water in Container A Another gram of pure Carbon 14 is mixed with 20 grams of water in Container B Which of the following is true with respect to Containers A and B

   a) The specific activities of C14 in Containers A and B are identical True/False

   b) The mixture in Container A produces more radiation than the mixture in Container B True/False

   c) The activities of C14 in Containers A and B are identical True/False

   d) The specific activity of the mixture in Container A is 10 times greater than the specific activity of the mixture in Container B True/False

5) If some nuclei in a group of identical atoms undergo spontaneous transformation to a lower potential energy state, the atoms in the group must be radioactive True/False

6) All nuclei which undergo spontaneous transformation to a lower potential energy state emit radiation True/False

7) All isotopes are radioactive Ture/False

8) The atomic nuclei of all isotopes of a given element contain the same number of _____

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9) A central problem in the field of health physics has to do with the uncertainty of predicting human responses to high doses of radiation True/False

10) If Substance A has a higher specific activity than Substance B, Substance A always produces more radiant energy than Substance B True/False

11) Curies and becquerels are units of radiation True/False

12) The only thing(s) which distinguish(es) gamma rays from microwaves is/are _____

RADIATION SAFETY COURSE
PROGRESS QUIZ 2

1) One becquerel is a unit of radioactivity equal to

a) 37×10^9 DPM
b) 37×10^9 DPS
c) 1 DPS
d) 1 photon per second

2) Match the following

picocurie	37×10^3 DPS
curie	37 DPS
millicurie	27×10^{12} curie
microcurie	37 billion DPS
nanocurie	37×10^3 DPS
becquerel	37×10^6 Bq

3) Alpha decay causes the atomic number of the parent to decrease by 4 True/False

4) If 232 is the mass number of a daughter which is produced by alpha decay, the parent must be an isotope of uranium True/False

5) Match the following

a) Electron Capture	a) A neutron is converted to a proton
b) Conversion Electrons	b) A nucleus de-excites by transferring energy to an orbital electron which is then ejected
c) Beta Emission	c) A proton is converted to a neutron
d) Gamma Rays	d) Has the same net effect on the nucleus as electron capture
e) Positron Emission	e) 4 AMU
f) Alpha Decay	f) Photons

6) Beta particles are monoenergetic True/False

7) A liquid scintillation counter detects photons which are produced in the scintillation fluid True/False

8) The source of beta emissions can be identified by measuring

a) The minimum beta energy
b) The average beta energy
c) The maximum beta energy
d) The energy of any one beta particle
e) Both items C and D above
f) Both items B and C above

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9) The half life of C14 is 5730 years If two half lives have elapsed in a quantity of C14 which originally contained 2 curies of C14, how much activity is left? _____

10) An equation which relates activity to elapsed time is $\frac{A}{A_0} = e^{-\lambda t}$

If $\frac{A}{A_0} = \frac{1}{2}$ for a quantity of C14, t must equal _____

RADIATION SAFETY COURSE
PROGRESS QUIZ 3

1) Some factors which help determine nuclear stability include (*Circle All Correct Responses*)

a) coulombic force of repulsion between protons
b) strong nuclear force which binds nucleons
c) proton to neutron ratio
d) mass number
e) nuclear cross section measured in barns

2) If the activities of parent and daughter are in equilibrium, their activities are equal True/False

3) If the half life of the daughter is longer than that of the parent, the activities of parent and daughter will eventually achieve

a) transitional equilibrium
b) secular equilibrium
c) no equilibrium

4) Radon gas is present in all three natural decay chains True/False

5) Is the following statement true or false?

Originally there were four natural decay chains One had such a short half life that it decayed to stability long ago, leaving only three in existence today The existing parents of the three decay chains are U-235, U-238 and Th-232 These radioisotopes and their decay products are found throughout the environment

6) C-14 is a decay product of a primordial radioisotope True/False

7) After a nucleus undergoes a transition by emitting a nuclear particle, the daughter nucleus is often left in an excited state This excess energy is released by the emission of a beta particle True/False

8) In nuclear physics, the letters "LET" stand for

a) Line Emission Tangent
b) Lepton Energy Transition
c) Lenticular Envelope Target
d) Linear Energy Transfer

9) LET is a measure of the charge density of ionizations created along the path of an ionizing particle or photon as it passes through an absorbing medium True/False

10) If three forms of ionizing radiation were arranged in descending order of LET, the proper order would be

a) 1] photon, 2] beta, 3] alpha
b) 1] beta, 2] photon, 3] alpha
c) 1] alpha, 2] beta, 3] photon
d) 1] alpha, 2] photon, 3] beta

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11) According to the inverse square rule, if three roentgens per hour of exposure is measured at a distance of 2 inches from a radiation source, the exposure rate at six inches should be *(Choose One)*

a) 3/16 roentgens/hour
b) 1 roentgen/hour
c) can't be calculated
d) 33 roentgens/hour

12) The manipulation of three factors allows a lab worker to control his/her exposure to external radiation produced by sources in a research lab These factors are a)_____, b)_____, c)_____

13) Draw a sketch of a simple ionization chamber which could be used to detect radiation

14) In some cases it is possible to identify a radioisotope by measuring the energy of a single particle or photon which is emitted when the radioisotope decays One case where this is <u>not</u> possible is when the radioisotope decays by

a) photon emission
b) beta emission
c) alpha emission

15) Match the following results of photon interactions with matter

a) Pair Production	a) Photon causes orbital electron to be ejected Photon disappears
b) Photoelectric Effect	b) The energy of a photon is manifested by the mass and kinetic energy of a positron and an electron which appear in place of the photon
c) Compton Scattering	c) Photon causes orbital electron to be ejected Photon remains in existence at reduced kinetic energy

16) Low Z materials make good shielding for photons, whereas high Z materials make good shielding for neutrons True/False

17) A "TLD" badge is an example of a solid state "scintillation" detector True/False

18) A photomultiplier tube is usually used in conjunction with an ionization chamber True/False

RADIATION SAFETY COURSE
FINAL EXAM

1 Three factors which a researcher can manipulate in order to control exposure to sources of external radiation in the laboratory are *(Fill in the Blank)* _____, _____, and _____

2 Three forms of radiation which are produced within a nucleus during nuclear disintegration are *(Fill in the Blank)* _____, _____, and _____

3 Which one of the following statements if correct? *(Circle the Correct Statement)*

A All isotopes are radioactive
B All isotopes contain the same number of neutrons
C One isotope can be composed of many chemical elements
D All isotopes of a chemical element contain the same number of protons

4 What is the difference between ionizing and non-ionizing electromagnetic radiation? *(Briefly Describe)*

_____
_____
_____

5 In general, alpha radiation is most dangerous when the dose is received *(Pick One)*

A Internally
B Externally

6 The chemical characteristics of a radioisotope and its compounds have no effect on the radiation hazard which may be associated with the radioisotope True/False

7 Bremsstralung radiation is emitted by a high speed electron as its angular momentum is changed by the coulombic force of attraction between the electron and a nearby nucleus True/False

8 Which of the following statements is correct? *(Circle the Correct Statement)*

A Becquerels and curies are units of radiation
B Half life is unrelated to activity
C The dose equivalent is a function of activity
D Activity is expressed in terms of roentgens per hour
E Millicuries per gram is an expression of specific activity

9 Very light elements make good shielding materials for photons True/False

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10 Given that the half life of Carbon 14 is 5,730 years and the equations

$$T_{\frac{1}{2}} = \frac{693}{\lambda}$$

$$\frac{A}{A_o} = e^{-\lambda t}$$

Where $T_{\frac{1}{2}}$ = Half life
λ = Decay constant
A = Activity after elapsed time t
A_o = Initial activity at time zero
e = Constant 2 718

Answer the following

If a piece of wood from an ancient temple is found to contain 2 49 microcuries of Carbon 14 per gram of wood and it is calculated that the wood contained 3 53 microcuries of Carbon 14 per gram of wood when it was part of a living tree, what is the probable age of the ancient temple?

11 *Match the Following*

A Roentgen	A Unit of absorbed dose
B RAD	B Unit of exposure
C REM	C Integrates internal and external doses
D TEDE	D Unit of dose equivalent

12 Which of the following forms of radiation has the highest LET? *(Circle One)*

A Photons
B Beta particles
C Alpha particles

13 Which one of the following statements is true? *(Circle One)*

A Cancer is a deterministic (non-stochastic) effect of radiation dose
B Reddening of the skin is a probabilistic (stochastic) effect of radiation dose
C The Annual Limit on Intake (ALI) is based on whichever is the least restrictive of the stochastic or non-stochastic dose limits
D If air monitoring determines that respiratory exposure in a lab exceeds the Derived Air Concentration (DAC), it is a sure sign that a worker in the lab will not reach the ALI in a year
E The occupational dose limit expressed in terms of Total Effective Dose Equivalent (TEDE) is 5 REM per year

14 The occupational dose limit for the fetus during the nine month gestation period is _____ *(Pick One)*

A 2 Roentgen
B 500 mREM
C 5 REM
D 5 μREM

ATTACHMENT 3

NOTIFICATION OF NEW USERS OF RADIOACTIVE MATERIAL

COLORADO SCHOOL OF MINES

Environmental Health and Safety (EHS)

Date _____

TO

FROM Bob MacPherson, Radiation Safety Officer

SUBJECT: Radiation Safety Program

The Environmental Health and Safety (EHS) office has been requested to issue you a radiation dosimeter and to include you in the School's Dosimetry Program We are happy to accommodate you and have ordered a dosimeter for your use You should receive it soon

As a participant in the School's Radiation Safety Program, there are some important things you should know Please take a moment to review the following information:

1 Radiation Exposure Records As required by state and federal law, the School maintains a cumulative record of occupational radiation exposure for each employee and student who participates in the dosimetry program In order to maintain an accurate cumulative record, I need to know if you were exposed to radiation at a previous academic institution or place of employment If you wore a dosimeter at a previous school or place of employment, please notify me right away I also need to know the name and address of the previous school or employer and the approximate inclusive dates of your previous participation in an institutional or employer's radiation dosimetry program This is an important health record that should follow you during your entire history of working with radiation and radioactive materials, so please don't forget or postpone your response My phone number is 273-3573 If I do not hear from you, I will assume that you have no previous record of exposure to radiation at a former school or place of employment

2 Supervised User Classification -- The School has established two categories of supervised users of radioactive material

A Direct Supervised Users are those who may handle radioactive materials only under the direct personal supervision and in the presence of the supervising faculty member who is personally authorized in the School's license to possess radioactive materials No formal training is required to qualify as a Direct Supervised User The supervising faculty member provides individualized training as needed

B Independent Supervised Users are those who may independently handle radioactive materials under the general supervision and in the absence of the supervising faculty member Ten hours of Radiation Safety Training (or equivalent) are required to qualify as an Independent Supervised User The supervising faculty member must certify in writing to me that prospective Independent Supervised Users have received ten hours of Radiation Safety Training and are recommended for designation as Independent Supervised

Users Persons who would like to acquire this training are invited to attend a 10-hour Radiation Safety Course which is offered each semester by the EHS office Call me at 273-3573 for details

Note that unsupervised handling of radioactive material by untrained persons is a serious violation of School policy and state law The EHS office strictly enforces these training requirements Please report any suspected violations to me immediately

You are presently designated as a _____
Supervised User of radioactive materials

3 Internal Radiation Exposure -- The School's dosimetry program assumes that your entire occupational dose is from external sources and that you will not have any internal dose due to inhalation, ingestion or absorption of licensed radioactive material If you ever suspect that you have or will receive an internal dose, please notify me immediately

4 Dose Limits For Pregnant Females -- The radiation dose limits for pregnant females are reduced due to increased risks of adverse health effects If you discover that you are pregnant during the time that you may handle radioactive materials or utilize an x-ray machine, I strongly recommend that you notify your supervising faculty member and me of your pregnancy. Upon such notification, I will meet with you to assess your radiation exposure and I will provide you with instructional materials to ensure that you understand the risks associated with radiation exposure during pregnancy It is very unlikely that any adjustment in your work will be required in order to stay within the reduced dose limits. This is because the historical occupational dose rates for all radiation workers at the School are already well within the reduced dose limits for pregnant women

Please call me at 273-3573 if you have any questions concerning the School's Radiation Safety Program

RAM/gk

ATTACHMENT 4

DOSE CALCULATION RECORD FORMS

Department Form OR-RH-17
(4/93)
PART 4

Radiation Control Division
Colorado Department of Health

OCCUPATIONAL EXPOSURE RECORD FOR A MONITORING PERIOD

1 NAME (LAST FIRST, MIDDLE INITIAL)	2 IDENTIFICATION NUMBER	3 ID TYPE	4 SEX ☐ MALE ☐ FEMALE	5 DATE OF BIRTH

6 MONITORING PERIOD	7 LICENSEE OR REGISTRANT NAME	8 LICENSE OR REGISTRATION NUMBER(S)	9A ☐ RECORD ☐ ESTIMATE	9B ☐ ROUTINE ☐ PSE

INTAKES

10A RADIONUCLIDE	10B CLASS	10C MODE	10D INTAKE IN ☐Bq or ☐μCi (Check one)

DOSES In ☐Sv or ☐Rem (Check one)

DEEP DOSE EQUIVALENT	(DDE)	11
EYE DOSE EQUIVALENT TO THE LENS OF THE EYE	(LDE)	12
SHALLOW DOSE EQUIVALENT, WHOLE BODY	(SDE,WB)	13
SHALLOW DOSE EQUIVALENT, MAX EXTREMITY	(SDE ME)	14
COMMITTED EFFECTIVE DOSE EQUIVALENT	(CEDE)	15
COMMITTED DOSE EQUIVALENT, MAXIMALLY EXPOSED ORGAN	(CDE)	16
(BLOCKS 11+15)	*(TEDE)*	17
MAX ORGAN *(BLOCKS 11+16)*	*(TODE)*	18

19 COMMENTS

20 SIGNATURE – LICENSEE OR REGISTRANT	21 DATE PREPARED

PAGE ____ OF ____

NRC FORM 4
(6 92)
10 CFR PART 20

U S NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB NO 3150-0005
EXPIRES

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: MINUTES. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE INFORMATION AND RECORDS MANAGEMENT BRANCH (MNBB 7714) U S NUCLEAR REGULATORY COMMISSION WASHINGTON DC 20555 AND TO THE PAPERWORK REDUCTION PROJECT (3150 0005) OFFICE OF MANAGEMENT AND BUDGET WASHINGTON DC 20503

CUMULATIVE OCCUPATIONAL EXPOSURE HISTORY

1 NAME (LAST FIRST MIDDLE INITIAL)			2 IDENTIFICATION NUMBER		3 ID TYPE	4 SEX: MALE ☐ FEMALE ☐	5 DATE OF BIRTH
6 MONITORING PERIOD		7 LICENSEE NAME		8 LICENSE NUMBER		9 RECORD ☐ ESTIMATE ☐ NO RECORD ☐	10 ROUTINE ☐ PSE ☐
11 DDE	12 LDE	13 SDE WB	14 SDE ME	15 CEDE	16 CDE	17 TEDE	18 TODE
6 MONITORING PERIOD		7 LICENSEE NAME		8 LICENSE NUMBER		9 RECORD ☐ ESTIMATE ☐ NO RECORD ☐	10 ROUTINE ☐ PSE ☐
11 DDE	12 LDE	13 SDE, WB	14 SDE ME	15 CEDE	16 CDE	17 TEDE	18 TODE
6 MONITORING PERIOD		7 LICENSEE NAME		8 LICENSE NUMBER		9 RECORD ☐ ESTIMATE ☐ NO RECORD ☐	10 ROUTINE ☐ PSE ☐
11 DDE	12 LDE	13 SDE WB	14 SDE ME	15 CEDE	16 CDE	17 TEDE	18 TODE
6 MONITORING PERIOD		7 LICENSEE NAME		8 LICENSE NUMBER		9 RECORD ☐ ESTIMATE ☐ NO RECORD ☐	10 ROUTINE ☐ PSE ☐
11 DDE	12 LDE	13 SDE WB	14 SDE ME	15 CEDE	16 CDE	17 TEDE	18 TODE
6 MONITORING PERIOD		7 LICENSEE NAME		8 LICENSE NUMBER		9 RECORD ☐ ESTIMATE ☐ NO RECORD ☐	10 ROUTINE ☐ PSE ☐
11 DDE	12 LDE	13 SDE WB	14 SDE ME	15 CEDE	16 CDE	17 TEDE	18 TODE
6 MONITORING PERIOD		7 LICENSEE NAME		8 LICENSE NUMBER		9 RECORD ☐ ESTIMATE ☐ NO RECORD ☐	10 ROUTINE ☐ PSE ☐
11 DDE	12 LDE	13 SDE WB	14 SDE ME	15 CEDE	16 CDE	17 TEDE	18 TODE
19 SIGNATURE OF MONITORED INDIVIDUAL		20 DATE SIGNED	21 CERTIFYING ORGANIZATION		22 SIGNATURE OF DESIGNEE		23 DATE SIGNED

NRC FORM 4 (6 92)

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ATTACHMENT 5

REPORT OF ANNUAL DOSE CALCULATIONS TO DOSIMETRY PROGRAM PARTICIPANTS

COLORADO SCHOOL OF MINES

Environmental Health and Safety (EHS)

, 1997

TO.

FROM. Bob MacPherson, Radiation Safety Officer

SUBJECT: Notification of Radiation Exposure During 1996

This is to inform you of the occupational radiation dose you received during calendar year 1996. Information concerning your external dose was obtained from your dosimeter readings during the year These dose calculations are based on the assumption that you did not receive an internal dose by way of skin absorption, inhalation or ingestion of radioactive liquids, particles, gases or vapors (excluding natural radioactive aerosols such as radon and its daughters) If you think this assumption is incorrect and that you did receive an internal dose, please contact me at Ext. 3573.

Various terms are used to express radiation dose These terms are defined in the attachment Dose limits are also described in the attachment Expressions of your dose in 1996 are as follows.

Deep Dose Equivalent	Rem
Eye Dose Equivalent to the Lens of the Eye	Rem
Shallow Dose Equivalent, Whole Body	Rem
Shallow Dose Equivalent, Maximally Exposed Extremity	Rem
Committed Effective Dose Equivalent	Rem
Committed Dose Equivalent	Rem
Total Effective Dose Equivalent	Rem
Total Organ Dose Equivalent	Rem

You are classified as:

- ☒ Authorized User of Licensed Radioactive Material
- ☐ Independent Supervised User
- ☐ Directly Supervised User
- ☐ Operator of Radiation-Producing Equipment
- ☐ Other

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There were 5 persons with this classification who participated in the CSM Dosimetry Program in 1996. For the sake of comparison, the highest expressions of dose among your peer group in 1996 were as follows:

Deep Dose Equivalent	Rem
Eye Dose Equivalent to the Lens of the Eye	Rem
Shallow Dose Equivalent, Whole Body	Rem
Shallow Dose Equivalent, Maximally Exposed Extremity	Rem
Committed Effective Dose Equivalent	Rem
Committed Dose Equivalent	Rem
Total Effective Dose Equivalent	Rem
Total Organ Dose Equivalent	Rem

Some Things To Remember For Your Health.

- Keep your exposure "As Low As Reasonably Achievable" (ALARA)
- Avoid skin contact, inhalation or ingestion of radioactive material Whatever goes into your body may irradiate sensitive tissues for the rest of your life.
- Avoid external exposure by utilizing time, distance and shielding to your advantage.

RAM/gk

DEFINITIONS

COMMITTED DOSE EQUIVALENT (CDE)

The dose equivalent to an organ or tissue that will be received from an intake of radioactive material during the 50-year period following the intake

COMMITTED EFFECTIVE DOSE EQUIVALENT (CEDE)

The sum of the products of the weighting factors and the committed dose equivalent to each irradiated organ or tissue

EYE DOSE EQUIVALENT (LDE)

The external dose equivalent to the lens of the eye at a tissue depth of 0 3 centimeter (300 mg/cm^2)

DEEP DOSE EQUIVALENT (DDE)

The Dose Equivalent at a tissue depth of 1 centimeter (1000 mg/cm^2) This applies to external whole body exposures

ROENTGEN EQUIVALENT MAN (REM)

The special unit of any of the quantities expressed as dose equivalent The dose equivalent in Rem is equal to the absorbed dose in Rad multiplied by the quality factor The Rem is the relative biological effectiveness of a given type of ionizing radiation expressed on a common scale

SHALLOW DOSE EQUIVALENT, WHOLE BODY (SDE,wb)

The dose equivalent at a tissue depth of 0 007 centimeter (7 mg/cm^2) averaged over an area of 1 square centimeter This applies to external exposure to the skin of the whole body

SHALLOW DOSE EQUIVALENT, MAXIMALLY EXPOSED EXTREMITY (SDE,me)

Shallow dose equivalent for the skin of the extremity receiving the maximum dose

TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE)

The sum of the deep dose equivalent for external exposures and the committed effective dose equivalent for internal exposures

TOTAL ORGAN DOSE EQUIVALENT (TODE)

The sum of the deep dose equivalent and the committed dose equivalent to the organ receiving the highest dose

DOSE LIMITS

A The annual limit for occupational exposures to an adult is the more limiting of

1 a Total Effective Dose Equivalent (TEDE) of 5 Rem,

2 the sum of the deep dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 Rem,

3 an eye dose equivalent of 15 Rem,

4 a shallow dose equivalent of 50 Rem to the skin or to any extremity

B The annual limit for occupational exposures to a minor is 1/10 of the above limits

C The dose to an embryo/fetus during the entire pregnancy of an occupationally exposed declared pregnant woman shall not exceed 500 millirem

ATTACHMENT 6

FORM FOR RECORDING FINDINGS OF ANNUAL SURVEY OF PUBLIC AREAS

ANNUAL SURVEY OF RADIATION EXPOSURE IN PUBLIC ACCESS AREAS

DATE:_____

CONDUCTED BY:_____

INSTRUMENT USED:_____

LOCATION	READING	REMARKS

8/27/97-Bobreprt/Table-7

SEALED SOURCE LEAK TEST RECORD 1997

Source ID#	Isotope/ Activity	User	Location	Freq	Remarks	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter		
						By	Date	Result	By	Date	Result	By	Date	Result	By	Date	Result
RH 119	Pu/Be 2Ci Neutron Source	Cecil	MH 147A	Q													
RH 144	Co 57 25 mCi	Williamson	MH 257	S													
RH 145	Co 57 25 mCi	Williamson	MH 257	S													
RH 146	Sn 119m 10 mCi	Williamson	MH 257	S													
RH 147	Co 5725 µCi	Williamson	MH 257	S													
RH 167	Ni63 15 mCi	Olson	HH 132	S	ECD Mod N610 0133 Ser 1993												
RH 168	Ni63 5 mCi	Seigrist	CO 029	S	ECD on GC												
RH 211	Ni 63 10 mCi	Mandernack	CO 148	S	ECD on Shimadzu GC	RM	2/5/97	< 005 µCi									
RH 212	Cm 244 160 mCi	Cecil	MH 147	S	Neutron/Gamma Source												
RH 158	Ni63 15 mCi	Macalady	CH 149	S	ECD 1658												
RH 159	Ni63 15 mCi	Wildeman	CH 260	S	ECD L0342												
RH 163	Co 57 25 mCi	Williamson	MH 257	S	Mossbauer Source 9654 DM												
RH 166	Cm 244 75 mCi	Cecil	MH 147	S													
RH 170	Th 230 005 µCi	Holub	CO 132	S													
RH 171	Th 230 006 µCi	Holub	CO 132	S													
RH 172	Th 230 - 004 µCi	Holub	CO 132	S													
RH 173	Th 230 009 µCi	Holub	CO 132	S													
RM 174	Th 230 008 µCi	Holub	CO 132	S													
RH 175	Th 230 - 006 µCi	Holub	CO 132	S													
RH 176	Th 230 003 µCi	Holub	CO 132	S													
RH 177	Th 230, 009 µCi	Holub	CO 132	S													

Source ID#	Isotope/ Activity	User	Location	Freq	Remarks	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter		
						By	Date	Result	By	Date	Result	By	Date	Result	By	Date	Result
RH 178	Th 230 - 006 µCi	Holub	CO 132	S													
RH 179	Th 230 - 003 µCi	Holub	CO 132	S													
RH 180	Th 230 - 007 µCi	Holub	CO 132	S													
RH 188	Am 241 006 µCi	Holub	CO 132	S													
RH 189	Am 241 - 2 µCi	Holub	CO 132	S													
RH 190	Cm 244 3 mCi	Cecil	MH 147	S													
RH 195	Am 241 - 02 µCi	Holub	CO 132	S													
RH 196	Ra 226 2 mCi	Holub	CO 132	S	Exempt from semi annual test												
RH 197	Ra 226 02 µCi	Holub	CO 132	S													
RH 198	Ra 226 1 µCi	Holub	CO 132	S													
RH 200	Ra 226 03 µCi	Holub	CO 132	S													

3/18/97 Bobreprt/Table 4H

ATTACHMENT 8

INVENTORY OF RADIATION PRODUCING EQUIPMENT

RADIATION PRODUCING EQUIPMENT INVENTORY

October 24, 1996

Machine	Location	Person in Charge	Remarks
Proton Accelerator General Ionics Model 1545 Serial 12991 Sticker # 33204	Meyer Hall Room 147	Ed Cecil, x3736	
XRD Scintag (1993) Model XGEN-4000 Serial XOS 2000 Sticker # 25119	Berthoud Hall Geology Lab Room 405	Rick Wendlandt, x3809	
XRF Rigaku (1981) Model 5 Max Serial DR13011 Sticker # 24995	Berthoud Hall Geology Lab Room 405	Charles Blount, x3452	
XRD Norelco/Phillips (1978) Model XRG-3100 Serial 1033 Sticker # 25115	Hill Hall X-Ray Lab Room 385	Steve Thompson, x3065	
XRF Norelco/Phillips (1976) Model XRG3100 Serial 1095 Sticker # 25116	Hill Hall X-Ray Lab Room 385	Steve Thompson, x3065	
XRD Rigaku (1980) Model RU200 Serial C14746 Sticker # 25117	Meyer Hall Room 257	Don Williamson, x3837	
XRD Siemens (1980) Kristalloflex 810 Sticker # 33205	Meyer Hall Room 257	Don Williamson, x3837	
XRD Nicolet I2/L11	Hill Hall Room 385	Thompson/Medlin	Donated by University of Wisconsin Machine not in service Date to put in service undetermined No inspection/certification

10/24/96 Gendoc/Table-E

ATTACHMENT 9

REMINDER NOTICES CONCERNING REDUCED DOSE LIMITS FOR PREGNANT WOMEN/MINORS AND REQUIREMENT TO POST "NOTICE TO EMPLOYEES"

COLORADO SCHOOL OF MINES

Environmental Health and Safety (EHS)

MEMO TO Faculty Supervisors of Radiation Producing Equipment

FROM Radiation Safety Officer

SUBJECT Radiation Safety

This is a reminder to faculty supervisors of x-ray machines and particle accelerators that maintenance of radiation safety procedures is essential Please review the following checklist and ensure that radiation safety procedures remain in effect

1 Posting of Signs and Notices A radiation warning sign should be posted on the door and a "Notice to Employees" should be posted in each laboratory A copy of the Notice to Employees is attached

2 Training Faculty members who supervise the use of x-ray machines and particle accelerators should provide documented, systematic training to all student, staff or faculty users of the machines There should be written authorization from the supervising faculty member which signifies that users have received appropriate training and are officially authorized to use the machine

3 Pregnancy All users of x-ray and particle accelerators should be notified that radiation dose limits for pregnant women are reduced due to risk of adverse health effects during pregnancy It should be strongly recommended, but not required, that women who use these machines advise you and me as soon as they discover they are pregnant If I receive such notification, I will meet with the "declared pregnant woman" and will provide her with information which is required by the Colorado Department of Public Health and Environment There is practically no possibility that the reduced dose limit will have any effect on anyone's work or studies since all of the radiation exposures at the School are already well within the limits for pregnant women

4 Dosimeters Persons who use radiation producing machines on a routine basis or for protracted periods should be utilizing personal dosimeters These are issued by my office upon request by you

The exposure of persons who utilize the machines infrequently should be monitored by affixing dosimeters in high risk target locations in the area around the machine These "area monitors" can be used to warn of machine malfunctions and operator error and can be used to approximate the dose to infrequent users of the machine I rely on you, the supervising faculty members, to submit requests for issuance of personal and area dosimeters and to ensure that dosimeters are properly used by machine operators

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5 Machine Inspection/Certification X-ray machines and particle accelerators may not be used unless the machine has been inspected and certified by a qualified inspector Certifications are valid for two years

6 Safety Devices Safety devices such as warning lights, shields and interlocks must remain in operation at all times

Please call me at 3573 if you require assistance or have questions Thanks

RAM/ge

8/26/97-Bob/Memos/Memo239

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[redacted] Radiation Control Division

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 4) NOTICES INSTRUCTIONS AND REPORTS TO WORKERS INSPECTIONS (PART 10) EMPLOYEE PROTECTION

RADIATION CONTROL DIVISION COLORADO DEPARTMENT OF HEALTH

The Radiation Control Division is the regulatory agency responsible for licensing and inspecting commercial medical therapy and research and development uses of radioactive materials and registering and inspecting radiation producing machines

RADIATION CONTROL DIVISION S RESPONSIBILITIES

The Radiation Control Division s primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation The Radiation Control Division does this by establishing requirements in the State of Colorado *Rules Regulations Pertaining to Radiation Control* 6 Code of Colorado Regulations (CCR) 1007 1 (Regulations)

EMPLOYER RESPONSIBILITIES

Any individual conducting activities licensed or registered by the Colorado Department of Health Radiation Control Division must comply with the Department s requirements If a violation of the Department s requirements occurs the license or registration can be modified suspended or revoked and/or the licensee or registrant can be fined

Your employer must tell you which Department radiation requirements apply to your work and must post Department Notices of Violation involving radiological working conditions

EMPLOYEE RESPONSIBILITY

For your own protection and the protection of your co workers you should know how Department requirements relate to your work and should obey them If you observe violation of the requirements you should report them

REPORTING VIOLATIONS

If you believe that violations of Department rules or of the terms of the license have occurred you should report them immediately to your supervisor If you believe that adequate corrective action is not being taken you may report this to a Department inspector or to the Radiation Control Division

WORKING IN A RADIATION AREA

If you work with or in the vicinity of radioactive materials or radiation producing machines the amount of radiation exposure that you may legally receive is limited by the Regulations The limits on your exposure as well as limits for an embryo/fetus are contained in Part 4 of the Regulations While those are the maximum allowable limits your employer should also keep radiation exposure as far below those limits as is reasonably achievable

OBTAINING A RECORD OF WORKER RADIATION EXPOSURE

If the Regulations require that your radiation exposure be monitored your employer is required to advise you annually of your dose In addition if you terminate employment with the licensee or registrant you may request at termination from your employer a report of your radiation exposure during the current year

IDENTIFYING VIOLATIONS OF DEPARTMENT REQUIREMENTS

The Department conducts regular inspections at licensed and registered facilities to assure compliance with Department requirements In addition your employer and site contractors conduct their own inspections to assure compliance

CONTACTING A DEPARTMENT INSPECTOR

Your employer may not prevent you from talking with a Department inspector and you may talk privately with an inspector and request that your identity remain confidential

REQUESTING AN INSPECTION

If you believe that your employer has not corrected violations involving radiological working conditions you may request an inspection Your request should be addressed to the Radiation Control Division Colorado Department of Health and must describe the alleged violation in detail It must be signed by you or your representative

CONTACTING THE DEPARTMENT

Notify a Department inspector on site or call the Radiation Control Division Department inspectors want to talk to you if you are worried about radiation safety or other aspects of licensed or registered activities

CAN I BE FIRED FOR RAISING A SAFETY ISSUE?

Federal law prohibits an employer from firing or otherwise discriminating against you for bringing safety concerns regarding licensed byproduct material source material or special nuclear material to the attention of your employer or the Department You may not be fired or discriminated against because you

- ask the Department to enforce its rules against your employer
- refuse to engage in activities which violate Department requirements
- provide information or are about to provide information to the Department or your employer about violations of requirements or safety concerns
- are about to ask for or testify help or take part in a Department Congressional or any Federal or State proceeding

NOTE These provisions do not apply to workers using only radiation producing machines (x ray machines)

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

It is unlawful for an employer to fire you or to discriminate against you with respect to pay benefits or working conditions because you help the Department or raise a safety issue or otherwise discourage you from engaging in protected activities

HOW AM I PROTECTED FROM DISCRIMINATION?

If you believe that you have been discriminated against for bringing violations or safety concerns to the Department or your employer you may file a complaint with the U S Department of Labor pursuant to Section 211 of the Energy Reorganization Act of 1974 (42 U S C 5851) Your complaint must describe the firing or discrimination and must be filed within 180 days of the occurrence

Send complaints to

Office of the Administrator
Wage and Hour Division
Room S3502
Employment Standards Administration
U S Department of Labor
200 Constitution Avenue NW
Washington DC 20210

or any local office of the Department of Labor Wage and Hour Division Check your telephone directory under U S Government listings

WHAT CAN THE DEPARTMENT OF LABOR DO?

The Department of Labor will notify the employer that a complaint has been filed and will investigate the case

If the Department of Labor finds that your employer has unlawfully discriminated against you it may order that you be reinstated receive back pay or be compensated for any injury suffered as a result of the discrimination

COLORADO SCHOOL OF MINES

Environmental Health and Safety (EHS)

MEMO TO Faculty Users of Licensed Radioactive Material

FROM Bob MacPherson, Radiation Safety Officer

SUBJECT Radiation Safety

This is a reminder to faculty members who possess licensed radioactive material that maintenance of radiation safety procedures is essential Please review the following checklist to ensure implementation of safety procedures and regulatory requirements

1 Supervised User Classification. There are two classifications of supervised users

A Direct Supervised Users are those who may handle radioactive materials under the direct personal supervision, and in the presence of the Authorized User (you) The Authorized User provides training as appropriate to Direct Supervised Users

B Independent Supervised Users are those who may handle radioactive materials under the general supervision of the Authorized User The Authorized User need not be present during these activities Persons become qualified to be Independent Supervised Users by attending a 10-hour Radiation Safety Course (or equivalent) This course is offered at the beginning of each semester

Please ensure that faculty, staff and students who handle your licensed radioactive material are trained and supervised in accordance with these classifications

2 Pregnant Women and Minors Women and minors should be advised at the outset of their work with radioactive materials, that the occupational dose limit for pregnant women and minors is much lower than occupational dose limits for other workers All female users of radioactive materials should be strongly encouraged (but not required) to notify the Authorized User (you) and the Radiation Safety Officer (me) as soon as possible upon discovery of pregnancy Upon notification, I will meet with "declared pregnant women" and explain the dose limits in detail

3 Wipe and Leak Testing Please ensure that you comply with the instrument survey or wipe testing methods and schedule which are prescribed in the Radioactive Materials license for each source in your possession Be sure to keep a record (Logbook — Date, Performed By, Radioisotope, Physical Form, Method, Result) of wipe tests or surveys The EHS office will perform required leak testing on sealed sources which are in your possession Routine wipe testing or instrument surveys for unsealed sources are your responsibility

4 Posting of Signs and Notices Radiation warning signs should be posted on laboratory doors In addition, a "Notice to Employees" should be posted in a visible location

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inside each laboratory A copy of the required Notice to Employees is attached A Hazardous Materials Emergency Information poster should also be displayed in the vicinity of each laboratory telephone These large laminated posters are available at the EHS office (Phone 3316) A sample copy is attached

5 Acquisition and Delivery of Sources All radioactive material must be purchased through the Chemical Storage and Distribution Facility in Coolbaugh Hall Contact John Elliott at 273-3555 for procurement service

All packages of radioactive materials should be initially delivered to John Elliott at the Chemical Storage and Distribution Facility Please ensure that you use the following delivery address for all radioactive materials·

Your Name
c/o John Elliott
Colorado School of Mines
Chemical Storage and Distribution Facility
Room 030
Coolbaugh Hall
1012 14th Street
Golden, CO 80401

Upon receipt of a radioactive package, John Elliott will perform the required package receipt survey, and will enter survey results in a record John will assign a unique source tracking number to each source in the package He will then deliver the package to you

6 Tracking of Sources It is essential that faculty supervisors maintain strict control of licensed sources The procedures for use, storage and handling must remain consistent with the conditions of the license amendment which justified acquisition of the source. If these conditions change, please notify me so that I can amend the license so that it reflects current usage

Upon delivery of new sources the EHS office applies an inventory number sticker to each source holder This number aids safety personnel in tracking the location and use of each licensed source Please ensure that sources are kept in the original source holders which bear the inventory numbers

Please call me if you require assistance in implementing the procedures outlined in this checklist

RAM/ge

8/26/97-Bob/Memos/Memo240

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NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 4) NOTICES INSTRUCTIONS AND REPORTS TO WORKERS INSPECTIONS (PART 10) EMPLOYEE PROTECTION

RADIATION CONTROL DIVISION COLORADO DEPARTMENT OF HEALTH

The Radiation Control Division is the regulatory agency responsible for licensing and inspecting commercial medical therapy and research and development uses of radioactive materials and registering and inspecting radiation producing machines

RADIATION CONTROL DIVISION S RESPONSIBILITIES

The Radiation Control Division s primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation The Radiation Control Division does this by establishing requirements in the State of Colorado *Rules Regulations Pertaining to Radiation Control* 6 Code of Colorado Regulations (CCR) 1007 1 (Regulations)

EMPLOYER RESPONSIBILITIES

Any individual conducting activities licensed or registered by the Colorado Department of Health Radiation Control Division must comply with the Department s requirements If a violation of the Department s requirements occurs the license or registration can be modified suspended or revoked and/or the licensee or registrant can be fined

Your employer must tell you which Department radiation requirements apply to your work and must post Department Notices of Violation involving radiological working conditions

EMPLOYEE RESPONSIBILITY

For your own protection and the protection of your co workers you should know how Department requirements relate to your work and should obey them If you observe violation of the requirements you should report them

REPORTING VIOLATIONS

If you believe that violations of Department rules or of the terms of the license have occurred you should report them immediately to your supervisor If you believe that adequate corrective action is not being taken you may report this to a Department inspector or to the Radiation Control Division

WORKING IN A RADIATION AREA

If you work with or in the vicinity of radioactive materials or radiation producing machines the amount of radiation exposure that you may legally receive is limited by the Regulations The limits on your exposure as well as limits for an embryo/fetus are contained in Part 4 of the Regulations While those are the maximum allowable limits your employer should also keep radiation exposure as far below those limits as is reasonably achievable

OBTAINING A RECORD OF WORKER RADIATION EXPOSURE

If the Regulations require that your radiation exposure be monitored your employer is required to advise you annually of your dose In addition if you terminate employment with the licensee or registrant you may request at termination from your employer a report of your radiation exposure during the current year

IDENTIFYING VIOLATIONS OF DEPARTMENT REQUIREMENTS

The Department conducts regular inspections at licensed and registered facilities to assure compliance with Department requirements In addition your employer and site contractors conduct their own inspections to assure compliance

CONTACTING A DEPARTMENT INSPECTOR

Your employer may not prevent you from talking with a Department inspector and you may talk privately with an inspector and request that your identity remain confidential

REQUESTING AN INSPECTION

If you believe that your employer has not corrected violations involving radiological working conditions you may request an inspection Your request should be addressed to the Radiation Control Division Colorado Department of Health and must describe the alleged violation in detail It must be signed by you or your representative

CONTACTING THE DEPARTMENT

Notify a Department inspector on site or call the Radiation Control Division Department inspectors want to talk to you if you are worried about radiation safety or other aspects of licensed or registered activities

CAN I BE FIRED FOR RAISING A SAFETY ISSUE?

Federal law prohibits an employer from firing or otherwise discriminating against you for bringing safety concerns regarding licensed byproduct material source material or special nuclear material to the attention of your employer or the Department You may not be fired or discriminated against because you

- ask the Department to enforce its rules against your employer
- refuse to engage in activities which violate Department requirements
- provide information or are about to provide information to the Department or your employer about violations of requirements or safety concerns
- are about to ask for or testify help or take part in a Department Congressional or any Federal or State proceeding

NOTE These provisions do not apply to workers using only radiation producing machines (x ray machines)

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

It is unlawful for an employer to fire you or to discriminate against you with respect to pay benefits or working conditions because you help the Department or raise a safety issue or otherwise discourage you from engaging in protected activities

HOW AM I PROTECTED FROM DISCRIMINATION?

If you believe that you have been discriminated against for bringing violations or safety concerns to the Department or your employer you may file a complaint with the U S Department of Labor pursuant to Section 211 of the Energy Reorganization Act of 1974 (42 U S C 5851) Your complaint must describe the firing or discrimination and must be filed within 180 days of the occurrence

Send complaints to

Office of the Administrator
Wage and Hour Division
Room S3502
Employment Standards Administration
U S Department of Labor
200 Constitution Avenue NW
Washington DC 20210

or any local office of the Department of Labor Wage and Hour Division Check your telephone directory under U S Government listings

WHAT CAN THE DEPARTMENT OF LABOR DO?

The Department of Labor will notify the employer that a complaint has been filed and will investigate the case

If the Department of Labor finds that your employer has unlawfully discriminated against you it may order that you be reinstated receive back pay or be compensated for any injury suffered as a result of the discrimination

HAZARDOUS MATERIALS EMERGENCY INFORMATION

(Post by Laboratory Telephones)

Chemical Spills The Environmental Health and Safety (EHS) Office provides a chemical spill response service EHS personnel are properly equipped to assist lab workers in cleaning up small-scale chemical spills Call the EHS office any time for an evaluation, information or spill cleanup assistance In the event of significant spills which pose an imminent threat of fire/explosion or poisoning, or in those circumstances where an immediate evacuation seems advisable, lab personnel should 1) sound the fire alarm to initiate an evacuation, 2) call the Fire Department, 3) call CSM Public Safety (Public Safety will notify the EHS Office)

ALL occupants must evacuate campus buildings whenever

1 The fire alarm sounds
2 An order to evacuate is given by the Fire Officer in charge, EHS Office personnel, Public Safety Officers, or the Department Head

Exercise of Authority If the Fire Department responds to an incident in a campus building, the Senior Fire Officer on the scene is in command All School personnel shall take direction from the Senior Fire Officer During such events, EHS personnel are the School's on scene representatives and coordinate activities with fire authorities If the Fire Department is not involved, EHS personnel are in charge and will coordinate with senior administrators in the building to resolve the problem

CSM Public Safety Officers are invested with police powers and may exercise command authority during emergencies

Chemical Exposure/Chronic Illness Lab personnel should be familiar with the hazardous characteristics of chemicals in the lab Call the EHS Office for information concerning flammability, toxicity, reactivity, etc , of chemicals and recommended safe handling procedures If physical symptoms appear which may be related to chemical exposure, call the EHS Office for an evaluation

Hazardous Waste The School provides a centralized hazardous waste collection and disposal service Call the EHS Office for information All chemical waste generated in laboratories is presumed to be "Regulated Hazardous Waste" unless determined otherwise by EHS personnel or other knowledgeable person DO NOT DUMP CHEMICALS DOWN THE DRAIN OR IN THE TRASH Participation in the School's Hazardous Waste Program is mandatory for all campus personnel who generate chemical waste Collection, transport or disposal of regulated waste by any other method is prohibited

EMERGENCY PHONE NUMBERS

EHS Office	273 3316
CSM Public Safety Office	278 0757
	273 3333
Golden Fire Department	9 911
Golden Police Department	9 911
Ambulance	9 911
Rocky Mountain Poison Center	629 1123

ATTACHMENT 10

NOTICES OF REQUIREMENT THAT WASTE GENERATORS MUST BE TRAINED AND AUTHORIZED

NOTICE CONCERNING MANDATORY SAFETY TRAINING
FOR NEW GRADUATE STUDENTS

Many graduate students at the Colorado School of Mines independently utilize highly regulated materials and potentially hazardous equipment during their course of study and research These materials and equipment include: highly toxic, flammable, corrosive or reactive gases and chemical reagents; federally regulated hazardous waste, radioisotopes, x-ray machines, and wood and metal working machinery In order to protect the environment and ensure the safety of individual students and occupants of buildings where these materials and equipment are housed, the School requires incoming graduate students to attend an introductory safety seminar which is provided each semester by the CSM Environmental Health and Safety (EHS) office The only graduate students who are excused from this training are those who will study economics, math or computer science All other new graduate students must attend the seminar on one of the dates listed below Engineering students who will not use chemicals or generate hazardous waste will be excused at the end of the first 30 minute training segment Other students who may utilize radioactive material, chemicals, compressed gases or generate chemical waste must attend the entire seminar The seminar lasts for about one and a half hours Snacks and drinks are provided The entire seminar is provided twice on separate dates at the beginning of each semester These optional dates are offered so that all incoming graduate students have an opportunity to attend No sign-up or reservation is required. The seminar schedule for the _____ semester, 19___ is.

	DATE	TIME	PLACE
1			
2			

Students who fail to attend the seminar on one of the above dates will be notified in writing by the Dean of Graduate Studies that they are not authorized to procure, use, store or handle chemicals on University premises In addition, these students will not be authorized to use wood or metal working machinery, radiation-producing equipment (x-ray machines), radioisotopes or generate regulated chemical waste A copy of this notification letter will be sent to the student's Department Head and Faculty Advisor The EHS office operates the central chemical procurement and distribution service and the chemical waste disposal service for the campus The EHS office will not respond to requests for these services from students who do not attend the seminar Please call the EHS Director at phone number (303) 273-3573 if you have questions concerning the requirement for you to attend

Sincerely,

Arthur Kidnay
Dean, Graduate Studies and Research

Bob MacPherson
Director, Environmental Health & Safety

5/28/97-Gendoc/Notice

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CSM

ENVIRONMENTAL HEALTH AND SAFETY (EHS)

TO DEPARTMENT HEADS

FROM Hazardous Materials Manager

SUBJECT Hazardous Material User Training

It is School policy that knowledge of, and participation in the School's Hazardous Waste Management Program is mandatory for persons who procure or use chemicals which eventually become waste Only designated faculty, students and classified staff members are authorized to generate federally regulated hazardous waste Authorization to generate waste is granted following attendance at a 45-minute hazardous waste training presentation **Graduate students and classified staff members must attend the 40-minute training presentation once a year in order to maintain authorization to generate hazardous waste or procure regulated materials.** Faculty members are permanently authorized to generate hazardous waste following attendance at one training presentation

If you wish to have additional persons receive the training and become authorized, please call me at 3998 to arrange a time for me to come to your department and provide the training **I am able to provide this presentation upon your request once per department per semester.**

The EHS Office maintains records of attendance at hazardous waste training presentations, and keeps a current list of campus personnel who are authorized to generate hazardous waste **The EHS Office will not provide chemical procurement or waste disposal services to persons who are not trained and authorized** If unauthorized persons in the department are found to be generating, storing, transporting or disposing of hazardous waste in an illegal manner, the entire cost for resolving the resultant waste management problem is chargeable to the department

Police officers may investigate mishandling of hazardous waste by unauthorized persons Civil and criminal charges may be brought against individuals who violate state and federal environmental law

Read instructions on back before filling out The information on this form must be accurate complete and legible Improperly filled out forms will not be accepted Inaccurate information could cause regulatory violation environmental degradation or severe safety hazards to persons who will handle this material

COLORADO SCHOOL OF MINES ENVIRONMENTAL HEALTH AND SAFETY PROGRAM

REQUEST FOR CHEMICAL RECYCLING AND WASTE DISPOSAL

Submit completed forms to
Environmental Health and Safety Office
Phone 273 3316
Call with questions or requests for assistance

① GENERATOR INFORMATION

DEPARTMENT _____ NAME OF PRINCIPAL INVESTIGATOR MAJOR PROFESSOR OR LABORATORY SUPERVISOR _____

BUILDING _____ NAME OF PREPARER _____

LOCATION OF WASTE TO BE COLLECTED (Room No) _____

② GENERATOR S CERTIFICATION

Date _____ Phone No _____

I certify that the contents of the waste containers listed on this form are fully and accurately identified

Printed Name _____ Signature _____

③ CONTAINER NO (Correspond with no on container tag)	E H S OFFICE USE T /	E H S OFFICE USE Comp	④ SPECIFIC CHEMICAL NAME/IDENTITY (If a mixture list all constituents Write chemical name not formulas common names or tradenames Indicate concentration of solutions or percentages by wright of each component of a mixture)	E H S OFFICE USE Consol	E H S OFFICE USE Empty	⑤ LIQUID/ SOLID/ GAS	⑥ QUANTITY OF WASTE in Kilograms (Kg)	⑦ CONTAINER SIZE AND TYPE (Glass metal plastic etc Volume in Liters)	⑧ FOR REUSE/ RECYCLING? Y/N

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ATTACHMENT 12

HAZARDOUS MATERIALS EMERGENCY INFORMATION POSTER

HAZARDOUS MATERIALS EMERGENCY INFORMATION

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Ambulance	9 911
Rocky Mountain Poison Center	629 1123

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RADIOACTIVE MATERIAL PACKAGE RECEIPT

DATE_____

I D of Radioactive Material_____

Package Size_____

Activity in Curies_____

Radioisotope I.D _____

Half-Life_____

Was package surveyed? _____ Yes _____ No

If surveyed, did package show leakage? _____ Yes _____ No

Name of Surveyor_____

Signature_____

ATTACHMENT 14

PROCEDURES FOR HANDLING RADIOACTIVE MINERAL SPECIMENS

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PROCEDURES FOR MANAGEMENT OF RADIOACTIVE MINERAL SPECIMENS

1 General Mineral specimens which contain more than 05% (500 ppm) uranium or thorium are regulated by the Colorado Department of Public Health and Environment (CDPHE), Radiation Control Division Campus personnel who acquire, possess, store, use, handle or dispose of radioactive mineral specimens must comply with provisions in State Radiation Control Regulations The School's Environmental Health and Safety office administers these regulations on the campus The Director of the Environmental Health and Safety is designated as the School's Radiation Safety Officer

2 Hazards Associated with Radioactive Mineral Specimens Three hazards are associated with radioactive mineral specimens

A Specimens release radon gas Radon and its decay products are alpha emitting radionuclides which cause irradiation of sensitive lung tissues when inhaled

B Many specimens are highly friable and produce airborne dust when handled Inhalation or ingestion of radioactive dust cause irradiation of sensitive tissues Radioactive material which enters the body may be retained for prolonged periods

C Specimens release gamma radiation which causes external exposure to penetrating radiation Some specimens have been found to have a surface exposure rate as high as 80 milliroentgens per hour Handling a specimen with an exposure rate in this range can result in a significant exposure to radiation

3 Coordinator

The Curator of the Geology Museum is designated as the Coordinator for acquisition, use, storage and disposal of all radioactive mineral specimens on the campus

4 Acquisition and Disposal of Radioactive Mineral Specimens

No one may acquire or dispose of radioactive mineral specimens without the prior approval of the Geology Museum Curator The Curator and the Radiation Safety Officer will specify handling procedures on a case-by-case basis

5 Storage

Room 506 in Berthoud Hall is the designated storage area for all radioactive mineral specimens on the campus (excluding specimens displayed in the Geology Museum) Specimens may not be stored in any other location The Museum Coordinator is in charge of this room and is the only person who can grant access Pregnant women and persons under the age of 18 are at greater risk to suffer adverse effects of radiation exposure and may not enter the storage area

6 Containment

All radioactive mineral specimens shall be kept in sealed plastic bags The bags prevent the release of particles which can be inhaled and which cause contamination of storage drawers

7 Checkout and Handling Procedures

Radioactive mineral specimens in plastic bags may be checked out of the Berthoud storage room by faculty members and graduate students The Museum Curator will coordinate

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checkout and return of specimens Specimens which are used for classroom display and demonstration shall not be taken out of plastic bags and should not be handled by students

If close examination or manipulation of specimens requires the removal of the plastic bags, the specimen shall be examined inside a fume hood Persons who handle unbagged specimens should wear rubber gloves Handling surfaces should be cleaned with a damp paper towel to remove particles The used paper towel should be placed in a plastic bag and returned to the Museum Curator along with the rebagged specimen

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ATTACHMENT 15

STATE FORM AND GUIDANCE CONCERNING LICENSE AMENDMENTS

STATE OF COLORADO
DEPARTMENT OF HEALTH

INSTRUCTIONS FOR PREPARATION OF APPLICATION FOR RADIOACTIVE MATERIAL LICENSE

An applicant for a new Radioactive Material License or for renewal of an existing Colorado Radioactive Material License must complete Form OR-RH-12 in detail. The applicant must cover the entire radioisotope program with one application. However, separate applications must be submitted for medical teletherapy and gamma irradiators. Supplemental sheets may be appended when necessary to provide complete information.

An applicant for an amendment to a Radioactive Material License need only complete Items 1, 3, 4, and 23 of Form OR-RH-12 in addition to those portions of Form OR-RH-12 which concern the desired changes. Supplemental sheets may be appended when necessary to provide complete information.

An application fee as specified in Part 12 of the State of Colorado *Rules and Regulations Pertaining to Radiation Control* must accompany each application for new license or amendment request. Except for licenses subject to full cost, no application for a new license, or for the reinstatement of an expired license, or for an amendment to an existing license will be accepted for processing prior to payment of the full amount specified in Part 12 of the Regulations. If you have any questions concerning fees please call the Department at (303) 692-3030 prior to submitting your application.

Two copies of the completed Form OR-RH-12 and attachments must be sent to the Colorado Department of Health, Radiation Control Division, 4300 Cherry Creek Drive South, Denver, CO 80222-1530. One copy must be retained by the applicant.

The submission of an incomplete application will often delay the issuance of the license because of the correspondence necessary to obtain information requested on the application. Pursuant to RH 12.4.1.1.3 of the Regulations, the Department will consider any application abandoned if the Department does not receive a reply within forty-five (45) days to its most recent request for additional information.

Item 1. The "Applicant" is the organization or person legally responsible for possession and use of the radioactive material specified in the application. This will usually be the corporate name of the company.

Item 2. Indicate the physical address(es) at which radioactive material will be used or stored if different from that listed in Item 1. A post office box number is not acceptable.

Items 3. and 4.
If the application is for renewal or amendment of an existing radioactive materials license then indicate the license number and expiration date of the license to be renewed or amended

Item 5. The "Department" is the company subdivision, if applicable, where the radioactive material will be used.

Item 6. List by element and mass number each radioisotope desired, such as "Carbon 14", "Cobalt 60", "Americium 241:Be", etc. See Item 6 in the example.

For **MEDICAL** applicants <u>groups</u> of radioactive materials may be requested by reference to specific sections of the Regulations. For example: the use of radiopharmaceuticals, generators, and reagent kits for imaging and localization are specified in RH 7 32 of the Regulations. See Item 6 F. in the example.

Item 7. List the chemical and/or physical form for each radioisotope identified in Item 6. If more than one chemical and/or physical form of a particular radioisotope is desired, a separate possession limit should be stated for each form. See Items 7.C and 7.D. in the example. If the radioactive material is to be obtained as a sealed source, specify the physical form as "sealed source" and include the manufacturer and model number for that sealed source See Item 7.A in the example

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Item 8. Specify the maximum amount of activity for each isotope listed in Item 6. If the radioactive source is a "sealed source," "foil," etc, then also state the number of sources the applicant desires to possess at any one time. See Item 8 in the example.

For **MEDICAL** applicants requesting radioactive materials in Items 6 and 7 by reference to RH 7.30, 7.32, 7.36, etc., the maximum amount of activity for all isotopes within those groups must be indicated. See Items 6.F., 7.F., and 8.F. in the example.

Item 9. State the use of each radioactive isotope and chemical/physical form specified in Item 6 and Item 7.

Example

6. Radioactive Material Element and Mass	7. Chemical/Physical Form Manufacturer and Model No.	8. Maximum Activity
A. Americium 241:Be	A. Sealed Source, Troxler Dwg. A-100337	A. 2 sources, 300mC each
B. Cobalt 60	B. Sealed Source, J L.Shepherd model 7810	B. 550 millicuries
C. Iodine 131	C. Iodide	C. 10 millicuries
D. Iodine 131	D. Iodinated Serum Albumin	D. 1 microcurie
E. Nickel 63	E. Foil, Safety Light model LAB-784	E. 100 millicuries
F. Radioactive materials authorized in RH 7.32 of the Regulations	F. Chemical and Physical form as authorized in RH 7.32 of the Regulations	F. 3 curies total

9. Purpose for Radioactive Material:

A. Used in a Troxler model 3241 series asphalt content gauge for asphalt content tests.
B. Used in a J.L. Shepherd model 28 calibrator for the calibration of survey instruments.
C. Used for In-Vitro analysis of rat thyroid tissue.
D. Used in laboratory studies of rats.
E. Used in a Philips Electronics model 134 detector cell for gas chromatography.

F. Used for imaging and localization as authorized in RH 7.32 of the Regulations.

Item 10. The "Individual Users" are the persons who will use unsupervised, or supervise the use of radioisotopes. If the application is for "human use," the individual user must be licensed by the State of Colorado to dispense drugs in the practice of medicine and meet the requirements of Part 7 of the Regulations regarding formal training and experience.

Item 11. Name of person designated as Radiation Safety Officer. Attach a description of the Radiation Safety Officer's duties and authorities. If the application is an amendment to change the radiation safety officer, it must be signed by someone other than the proposed Radiation Safety Officer.

Item 12. Submit evidence that the individual designated as Radiation Safety Officer has had training appropriate to the types of radioactive materials, activities, and uses identified in this application. **Attach copies of any certifications awarded.**

Training considered essential to the safe use of radioactive materials includes.
A. Principles and practices of radiation protection.
B. Radioactivity measurement standardization and monitoring techniques and instruments.
C. Mathematics and calculations basic to the use and measurement of radioactivity.
D. Biological effects of radiation

Item 13. List the experience with radioactive materials for the individual designated as Radiation Safety Officer.

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Item 14. Submit evidence that the individual users have had training appropriate to the types of radioactive materials, activities, and uses identified in this application. If more than one individual is named in Item 10, clearly key the name of each individual to his/her training **Attach copies of any certifications awarded to each individual.**

Topics considered essential to the safe use of radioactive materials include:
A. Principles and practices of radiation protection.
B. Radioactivity measurement standardization and monitoring techniques and instruments.
C. Mathematics and calculations basic to the use and measurement of radioactivity.
D. Biological effects of radiation.

Item 15. List the experience with radioactive materials for the individual user of radioactive materials. If more than one individual is named in Item 10, clearly key the name of each individual to his/her experience.

For **MEDICAL** applications, individuals may also have to submit a signed and dated Form OR-RH-13 to demonstrate clinical training and experience.

Item 16. Identify the radiation detection instruments and probes that will be used in conjunction with your radioactive materials program. Describe how the instruments will be used (area surveys, contamination surveys, wipe counting, etc.). The instrument and probe must be capable of detecting the emissions from the specific radioactive materials for which the survey is being conducted. Also, the sensitivity and efficiency of the instrument must be appropriate for the type of use.

Item 17. Submit a copy of your calibration procedures.

A. The calibration of a survey instrument must be made with an appropriate radioactive source which is traceable to the National Institute for Standards and Technology (NIST).

B. The individual performing the calibration must have at least 40 hours of formal course work and 1 week of on-the-job training. The topics of the formal training are outlined in Item 12. of these instructions. The on-the-job training must include hands-on experience in calibrating instruments.

C. If the instrument cannot be calibrated to within 20% of the actual activity, the instrument must be returned to manufacturer for repair or a graph or table of correction factors must be attached to the instrument.

If a commercial service is to be used, the company must be licensed to provide that service. Submit the company's name, address, and license number.

Item 18. The supplier of film badges and TLD's must be approved by the National Voluntary Laboratory Accreditation Program (NVLAP). The frequency of exchange for film badges and TLD's must not exceed 1 month and 3 months respectively. If an audible radiation dosimeter or pocket dosimeter is used then specify the manufacturer and model of the dosimeter used. Also specify the frequency and procedures for the calibration of these dosimeters.

Item 19. A. Specify the types of equipment that will be used in conjunction with radioactive materials. Examples would include remote handling devices, fume hoods, lead shields, storage containers, shipping containers, lead aprons, and other safety equipment.

Item 19. continued

B. The sketch of your facility must be sufficiently detailed to give a clear picture of your facility in relation to radioactive material usage.

Clearly identify the locations or areas where·
1) radioactive materials are used and stored;
2) special equipment and shielding are used;
3) area surveys and wipes will be conducted;
4) fume hoods and exhaust vents are used;
5) fume hoods and exhaust vents are discharged to the outside air,
6) radioactive materials warning signs and notices are posted;
7) non-radiation workers or the general public will have access.

Item 20. The description of your radiation protection program must cover the entire scope of your radioactive materials usage, including:

1) Procedures to keep personnel exposures ALARA
2) Procedures for the safe use of radioactive materials
3) Personnel monitoring procedures
4) Emergency procedures
5) Procedures to ensure adequate security of radioactive materials
6) Procedures for storage of radioactive materials
7) Procedures for contamination control
8) Procedures for receiving and shipping radioactive materials. All shipments of radioactive materials must meet the requirements of the U.S. Department of Transportation. Include procedures for surveying packages, receipt of materials after business hours, and for handling contaminated or leaking packages.
9) Procedures for leak testing sealed sources and describe actions to be taken if a sealed source if found to be leaking. The test must be capable of detecting 0.005 microcurie of removable activity.
10) If radioactive materials will be used in normal form, submit:

A. Procedures of conducting area surveys and wipes. Describe the lowest level of contamination detected, and specify the levels of contamination which will require clean-up.

B. Procedures for the clean-up of spills involving radioactive materials.

11) If a commercial service is employed to determine the level of contamination on wipes from leak tests or area surveys, then specify the name of the company, address, and license number.

12) If the licensee will determine the level of contamination on wipes, then submit detailed procedures for counting wipes and a description of the equipment used.

13) If the licensed activities involve operations which utilize, at any one time, more than 100 millicuries of Hydrogen 3 in a non-contained form, other than metallic foil, then submit procedures for performing bioassays and evaluating the test results.

14) If the licensed activities involve operations which utilize, at any one time, more than 50 millicuries of I-125 and/or I-131 or unvented laboratory operations involving 10 millicuries of I-125 and/or I-131, then submit procedures for performing bioassays and evaluating the burden to the thyroid.

15) If the licensed activities involve the transportation of radioactive materials, then submit transportation procedures. The transportation of radioactive materials must satisfy the requirements of the U.S. Department of Transportation and other agencies having jurisdiction Your procedures must include the prompt notification of this Division in the event of an accident involving radioactive materials.

16) If the licensee will provide training to its personnel involving the use of radioactive materials, then submit an outline of the course, the numbers of hours of instruction given to personnel, frequency of training, and the qualifications of the person who will give the training. Also describe the duties of the individual receiving this training. If separate classes are given to different types of employees, then describe each program.

17) If the licensed activities involve the **Medical Use** of radioactive materials, then:

A. Describe your ALARA program.
B. Describe your Radiation Safety Committee, including its members, the frequency of meetings, and its responsibilities.
C. Submit procedures for the safe use of radiopharmaceuticals.
D. Submit procedures for the control of radioactive aerosols and gases.
E. Submit procedures for safety during nuclear medicine therapy.
F. Submit procedures for the calibration of dose calibrators.
G. Submit procedures for the control of molybdenum 99 concentrations.
H. Submit procedures for the calibration of imaging equipment.

Item 21. Submit procedures for the disposal of sealed sources, radioactive waste, and contaminated items. Also estimate the amount of waste expected to be generated each year.

A. If radioactive materials will be stored for decay, then the waste **MUST** be stored a minimum of 10 half-lives. All waste **MUST** be surveyed prior to disposal and the waste **MUST** be indistinguishable from background. The survey must be conducted with all shielding removed, in a low background area with an appropriate instrument. In addition to the survey, all radioactive labels must be removed or obliterated.

B. If radioactive materials will be disposed of via the sewer system, then submit your procedures and calculations which demonstrate that the release limits specified in RH 4.18 are not exceeded.

If a commercial waste disposal service is employed, then specify the name of the company, address, and license number. Also describe the services provided.

RADIUM: The licensee must furnish evidence of the licensee's ability to lawfully dispose of the Radium source(s) to be possessed by the licensee. The evidence must include the name and address of the company/licensee to which the source(s) would be sent for disposal during the period of time this license is valid. The evidence must also include the ability of the receiving company/licensee to receive such source(s). The ability to dispose of the Radium source(s), and documents supporting that ability, must be maintained by the licensee until lawful disposal of the Radium source(s) has been completed.

NOTE: Beginning January 1, 1993 greater than Class C quantities of radioactive waste are not acceptable at the available low-level waste site. Until the Department of Energy develops a waste site for greater than Class C wastes you will most likely have to store such sources at your location unless such sources can be returned to the vender. Refer to RH 4.22 for the classification of waste.

Item 22. Demonstrate that the requirements of RH 3.9.4 have been satisfied. The requirements for financial assurance are based on the isotope, physical form, and activity of licensed materials.

Item 23. The individual signing the application for an institution must hold a position of responsibility for that institution. The certificate must be signed and dated.

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STATE OF COLORADO
DEPARTMENT OF HEALTH

APPLICATION FOR RADIOACTIVE MATERIAL LICENSE

INSTRUCTIONS: Refer to form OR-RH-11 for detailed instructions in completing this application. This application must be signed and dated. Mail two copies to Colorado Department of Health, Radiation Control Division, 4300 Cherry Creek Drive South, Denver, Colorado 80222-1530. All licenses are issued in accordance with the general requirements contained in the State of Colorado *Rules and Regulations pertaining to Radiation Control* and 25-11, CRS 1989, Replacement volume, as amended.

New Application:_____ Renewal:_____ Amendment:_____

1. Applicant Name:

_____
Mailing Address

_____
City State Zip

_____
Phone Number ( )

2. Location of Use:

_____
Street Address

_____
City State Zip

_____
Phone Number ( )

3. Current or Previous License No:_____

4. Expiration Date:_____

5. Department to use Radioactive Material:_____

6. Radioactive Material Element and Mass	7. Chemical/Physical Form Manufacturer and Model No.	8. Maximum Activity
A._____	A._____	A._____
B._____	B._____	B._____
C._____	C._____	C._____
D._____	D._____	D._____
E._____	E._____	E._____
F._____	F._____	F._____
G._____	G._____	G._____

9. Purpose for Radioactive Material.

A._____
B._____
C._____
D._____
E._____
F._____
G._____

10. Individual Users:

A._____	E._____	I._____
B._____	F._____	J._____
C._____	G._____	K._____
D._____	H._____	L._____

11. Radiation Safety Officer:_____

TRAINING AND EXPERIENCE OF RADIATION SAFETY OFFICER

Radiation Safety Officer:_____

12. Training

Subject:_____

Type of Training:	Hours in Training	Dates and Locations of Training
Formal Course____	_____	_____
On The Job____	_____	_____
Seminar____	_____	_____

Subject:_____

Type of Training:	Hours in Training	Dates and Locations of Training
Formal Course____	_____	_____
On The Job____	_____	_____
Seminar____	_____	_____

Subject:_____

Type of Training:	Hours in Training	Dates and Locations of Training
Formal Course____	_____	_____
On The Job____	_____	_____
Seminar____	_____	_____

Degrees awarded:_____
Major:_____
College or University attended:_____
Dates:_____

13. Experience with radiation

Isotope: _____ Type of use:_____
Activity:_____ Where experience was gained:_____
Chemical/Physical Form:_____ Dates of experience: From_____To_____

Isotope: _____ Type of use:_____
Activity:_____ Where experience was gained:_____
Chemical/Physical Form:_____ Dates of experience: From_____To_____

Isotope: _____ Type of use:_____
Activity:_____ Where experience was gained:_____
Chemical/Physical Form:_____ Dates of experience: From_____To_____

Isotope: _____ Type of use:_____
Activity:_____ Where experience was gained:_____
Chemical/Physical Form:_____ Dates of experience: From_____To_____

Isotope: _____ Type of use:_____
Activity:_____ Where experience was gained:_____
Chemical/Physical Form._____ Dates of experience: From_____To_____

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TRAINING AND EXPERIENCE OF INDIVIDUAL USER

Individual User:__________________________

14. Training

Subject:____

Type of Training:	Hours in Training	Dates and Location of Training
Formal Course____	__________	____________________
On The Job____	__________	____________________
Seminar____	__________	____________________

Subject:____

Type of Training:	Hours in Training	Dates and Location of Training
Formal Course____	__________	____________________
On The Job____	__________	____________________
Seminar____	__________	____________________

Subject:____

Type of Training:	Hours in Training	Dates and Location of Training
Formal Course____	__________	____________________
On The Job____	__________	____________________
Seminar____	__________	____________________

Degrees awarded:____
Major:____
College or University attended:________________________________
Dates:____

15. Experience with radiation

Isotope: __________ Type of use:____________________________
Activity:__________ Where experience was gained:_________________
Chemical/Physical Form:________________ Dates of experience: From__________To________

Isotope: __________ Type of use:____________________________
Activity:__________ Where experience was gained:_________________
Chemical/Physical Form:________________ Dates of experience: From__________To________

Isotope: __________ Type of use:____________________________
Activity:__________ Where experience was gained:_________________
Chemical/Physical Form:________________ Dates of experience: From__________To________

Isotope: __________ Type of use:____________________________
Activity:__________ Where experience was gained:_________________
Chemical/Physical Form:________________ Dates of experience: From__________To________

Isotope: __________ Type of use:____________________________
Activity:__________ Where experience was gained:_________________
Chemical/Physical Form:________________ Dates of experience: From__________To________

16. **RADIATION DETECTION INSTRUMENTS**

Manufacturer and Model of Instrument:_____
Manufacturer and Model of Probe:_____
Radiation Detected:_____ Efficiency:_____
Sensitivity Ranges:_____ Number of Instruments Available:_____
How Used:_____

Manufacturer and Model of Instrument:_____
Manufacturer and Model of Probe:_____
Radiation Detected:_____ Efficiency:_____
Sensitivity Ranges:_____ Number of Instruments Available:_____
How Used:_____

17. **CALIBRATION OF RADIATION DETECTION INSTRUMENTS**

Attach a copy of your calibration procedures. If a commercial service is to be used, provide the name, address and license number of the company.
Name:_____ License Number:_____
Address:_____
_____

Frequency Calibrated:_____ Maximum Acceptable Deviation:_____%
Corrective Action:_____
Calibration Sources MUST be traceable to NIST.
Calibration Sources Used: Isotope_____ Activity_____
Isotope_____ Activity_____

18. **FILM BADGES AND DOSIMETERS** **The supplier MUST be approved by NVLAP.**

Type of Device	Radiation Detected	Frequency Exchanged	Name and Address of Supplier:
Film Badge ____	_____	_____	
TLD ____	_____	_____	_____
Other:_____	_____	_____	_____
			_____

Audible Radiation Dosimeter is used: Yes___ No___
Pocket Dosimeter is used: Yes___ No___

19. **FACILITIES AND HANDLING EQUIPMENT**

A. Attach a description of the types of counting, handling, and safety equipment used in connection with radioactive materials.

B. Attach an explanatory sketch of your facility. Identify the locations of special handling equipment, fume hoods, storage containers, shielding, safety equipment, etc. Also identify the locations where radioactive material warning signs, Notice to Employees, and emergency telephone numbers are posted.

20. **RADIATION PROTECTION PROGRAM**

Attach a description of your radioactive materials program. See the instructions for a more complete listing of the needed information. The information must reflect your current program and procedures.

21. **WASTE DISPOSAL**

A. Attach procedures for the disposal of radioactive waste.

B. If a commercial service is to be used, then also specify the name, address, radioactive materials license number and expiration date, of the company providing the services. Also describe the types of services provided.

Name and Address:_____ License No:_____
_____ Expiration Date:_____
_____

Description of services provided:_____
_____
_____
_____
_____
_____

22. **FINANCIAL ASSURANCE**

A. Documentation of a financial assurance is attached: Yes____ No____

B. An application for exemption from financial assurance is attached: Yes____ No____

23.

CERTIFICATE

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATE ON BEHALF OF THE APPLICANT NAMED IN ITEM 1, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH COLORADO DEPARTMENT OF HEALTH RADIATION CONTROL REGULATION AND THAT ALL INFORMATION CONTAINED HEREIN, INCLUDING ANY SUPPLEMENTS ATTACHED HERETO, IS TRUE AND CORRECT TO THE BEST OF OUR KNOWLEDGE AND BELIEF.

_____
Applicant named in Item 1

By:_____ Date:_____

_____
(Printed or Typed name)

_____
Title of certifying official authorized
to act on behalf of the applicant

HOW DO I DEMONSTRATE THAT I CAN MEET RH 4.14 AND 4.15?

Revisions to Part 4 of the State of Colorado *Rules and Regulations Pertaining to Radiation Control* were implemented on January 1, 1994, changing the radiation dose limits for individual members of the public from licensed radioactive materials Under the new requirements, a licensee or registrant shall conduct operations so that. (1) the dose in any unrestricted area from external sources does not exceed 2 millirems in any one hour, and (2) the dose to individual members of the public does not exceed 100 millirems in a year.

Before the Department can issue or amend a radioactive materials license, it must be determined that you <u>can</u> meet these general public dose limits. The dose limits apply to the actual doses received from licensed materials. However, the determination that you can meet the limits is based upon the types and quantities of materials which you have requested and the facilities in which they will be stored and used When the Department issues a radioactive materials license, the license authorizes you to possess the maximum quantity identified on the license. Therefore, you must demonstrate that you can meet all applicable requirements for the maximum quantity requested

The following guidance can be used to demonstrate that you <u>can</u> meet these requirements with the quantities of materials requested on the license.

1 A "restricted area" means an area, access to which is limited or controlled by the licensee or registrant for purposes of protecting individuals against exposure to sources of radiation Anyone who can frequent a restricted area must be properly trained and must wear personnel monitoring, unless it has been determined that the individual will receive less than 10% of the occupational dose limit

in millirems per hour at one meter from the outside of the gauge shipping container. A total TI can be assumed to be the TI for a single gauge, multiplied times the number of similar gauges For example, if the TI is "1 5" and you have five identical gauges, you may estimate the total dose rate at one meter to be 1 5 x 5, or 7 5 millirems per hour.

If a source has a measured dose rate at a given distance, and then you move away from the source, the dose rate will decrease with the square of the distance. That is, if you double the distance from a source you decrease the dose rate by a factor of four The formula for this calculation is given below

$$R_2 = \frac{R_1 (D_1)^2}{(D_2)^2}$$

EXAMPLE: If the dose rate at one meter from a source is 12 millirems per hour, what would be the expected dose rate at 3 meters?

R_2 = ?

R_1 = 12 millirems per hour

D_1 = 1 meter

D_2 = 3 meters

R_2 = 12 x 1/9

R_2 = 1 33 millirems per hour

5 Dose rates must be multiplied by the time period of the possible exposure. For an individual over which you have no control (i.e , a neighboring house or office) you must assume an exposure time of 24 hours per day for 365 days per year, or 8760 hours For general public within your facility, which you do control, the exposure time may be 8 hours per day, five days per week, for 50 weeks per year (2000 hours per year) For example, a full time secretary for the

brick or concrete walls. Books are available regarding shielding calculations and materials. However, a qualified expert or the manufacturers representative should be able to perform calculations for the shielding provided by existing walls, or to design additional shielding, as necessary

8 To demonstrate that you can meet 2 millirems per hour, and 100 millirem per year to a member of the public, submit a diagram together with the calculated or actual measurements of radiation dose rate for each area adjacent to the storage area. This should also include above and below the storage are if these are occupiable areas. Include with the measurements a "background" measurement, which is the radiation dose rate from the natural environment (excluding all licensed radioactive materials). Also include any assumptions you have made regarding occupancy. If you are authorized multiple storage locations, compliance with the dose rate and annual dose limit to the general public must be demonstrated for each location.

(Hallways, unattended parking lots - occupancy factor is 1/4)

(Stairways, toilets, sidewalks - occupancy factor is 1/16)

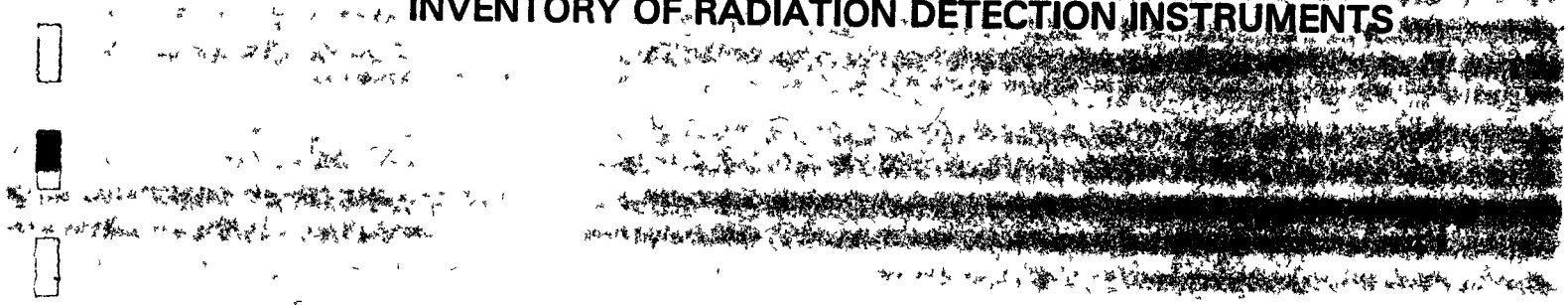
(9) Estimated dose to the member of the general public

(line 6 x line 7 x line 8) _____ mr per year.

If the dose calculated in (9) is greater than 100 millirem per year, you do not meet RH 4.14 of the Regulations, and you must increase the distance to the member of the general public or add shielding If the calculated dose is less than 100 millirem per year, you have demonstrated that you can meet RH 4.14, for that particular member of the general public The calculations in (7) through (9) must be repeated for other members of the general public and occupiable areas which may have a different occupancy factor and distance.

ATTACHMENT 16

INVENTORY OF RADIATION DETECTION INSTRUMENTS



RADIATION DETECTION INSTRUMENTS
DATE AUGUST 26, 1997

ITEM NO	MANF /MODEL NO OF INSTRUMENT	MANF /MODEL NO OF PROBE	RADIATION DETECTED	EFFICIENCY	SENSITIVITY RANGE	HOW USED	POSSESSION/ LOCATION
1	Ludlum Model 19 Micro R Meter	Not Applicable	Gamma	Varies with radioisotope	Varies with radioisotope	General Survey	MacPherson/EHS Office
2	Ludlum Model 12S Micro R Meter	Not Applicable	Gamma	Varies with radioisotope	Varies with radioisotope	General Survey	Williamson/MH 257
3	Ludlum Model 2221 Scaler/Ratemeter	Ludlum Model 44 2 Gamma Scintillator	Gamma	Varies with radioisotope	Varies with radioisotope	General Survey	Honeyman/CO 236
4	Ludlum Model 177 Alarm Ratemeter	Ludlum 44 9 G M Pancake	Alpha, Beta, Gamma	Varies with radioisotope	Varies with radioisotope	Entry/Exit Frisk General survey	Honeyman/CO 236
5	Ludlum Model 14C Geiger Counter	Ludlum 44 9 G M Pancake	Alpha Beta, Gamma	Varies with radioisotope	Varies with radioisotope	General Survey	MacPherson/EHS Office
6	Technical Associates PUG 1AB	G M Pancake	Alpha, Beta, Gamma	Varies with radioisotope	Varies with radioisotope	General Survey	Williamson/MH 257
7	Ludlum Model 177 Alarm Ratemeter	Ludlum Model 43 65 Alpha Scintillator	Alpha	Varies with radioisotope	Varies with radioisotope	Entry/Exit Frisk General Survey	Honeyman/CO 236
8	Eberline Model ESP 1 Ratemeter/Scaler	Eberline Neutron rem Detector Model NRD	Neutrons	Varies with radioisotope	Varies with radioisotope	Neutron Survey/Calib	Cecil/MH 147
9	Ludlum Model 14C Geiger Counter	Ludlum 44 9 G M Pancake	Alpha Beta, Gamma	Varies with radioisotope	Varies with radioisotope	General Survey	Wendlandt/BH
10	Packard Model 1600 Liquid Scintillation Counter	Not Applicable	Alpha, Beta, Gamma	Varies with radioisotope	Varies with radioisotope	Wipe Sample Count Research	Honeyman/CO 236
11	Packard Model 2500 Liquid Scintillation Counter	Not Applicable	Alpha, Beta, Gamma	Varies with radioisotope	Varies with radioisotope	Wipe Sample Count Research	Honeyman/CO 236
12	Ludlum Model 2000 Scaler/Timer	Ludlum Model 43-10 and Sample Counter	Alpha	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236

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ITEM NO	MANF /MODEL NO OF INSTRUMENT	MANF /MODEL NO OF PROBE	RADIATION DETECTED	EFFICIENCY	SENSITIVITY RANGE	HOW USED	POSSESSION/ LOCATION
13	Canberra High Purity Germanium Gamma Spectrometer Model GR 1320	Not Applicable	Gamma	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236
14	Canberra Alpha Spectrometer Model 7401 (4 detectors)	Not Applicable	Alpha	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236
15	E G and G Ortec Alpha Spectrometer (8 detectors) Model Alpha 8	Not Applicable	Alpha	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236
16	Tennelec Alpha Spectrometer Model TC 256 (1 detector)	Not Applicable	Alpha	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236
17	E G and G Ortec Model 808 Alpha Spectrometer (1 detector)	Not Applicable	Alpha	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236
18	Ordela Perals Model 8100 AB Alpha Liquid Scintillation Spectrometer	Not Applicable	Alpha	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236
19	Tennelec/Nucleus LB 4110 Gas Proportional Counter	Not Applicable	Alpha, Beta	Varies with radioisotope	Varies with radioisotope	Research	Honeyman/CO 236