NRC FORM 313
(10-87)
10 CFR 30, 32, 33, 34, 35 and 40

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED BY OMB
3150-0120
Expires: 6-30-90

APPLICATION FOR MATERIAL LICENSE

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATIONS FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS. IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIALS SAFETY SECTION B
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
NUCLEAR MATERIALS SAFETY SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
NUCLEAR MATERIALS SAFETY SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*

- [ ] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER _____
- [X] C. RENEWAL OF LICENSE NUMBER SNM-116

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip Code)*

University of Wisconsin
Reactor Director
142 Mechanical Engineering Bldg.
Madison, WI 53706

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED.

Madison campus of the University of Wisconsin

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

R. J. Cashwell

TELEPHONE NUMBER: 608-262-3392

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL
a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time.

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.

9. FACILITIES AND EQUIPMENT.

10. RADIATION SAFETY PROGRAM.

11. WASTE MANAGEMENT.

12. LICENSE FEES *(See 10 CFR 170 and Section 171.31)*
FEE CATEGORY: N/A
AMOUNT ENCLOSED: $ 0

13. CERTIFICATION. *(Must be completed by applicant)* THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN, IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

SIGNATURE—CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
R Cashwell	R. J. Cashwell	Reactor Director	

9002010038 890323
REG3 LIC70
SNM-0116 PDR

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	COMMENTS	APPROVED BY
Ren	Dual	E X I K	EXEMPT 170.11 (a)(9)	CP
AMOUNT RECEIVED	CHECK NUMBER		CONTROL NO 85561	DATE 6/20/86

5. Byproduct, source, and/or special nuclear material	Chemical and/or physical form	Maximum amount that licensee may possess at any one time under this license
A. Plutonium 239	A. Sealed neutron sources	A. 80 grams total (Five sources of 1 curie each)
B. Plutonium 239	B. Plated Alpha Sources	B. 12.7 micrograms
C. Uranium	C. Enriched uranium as plated sources in fission detectors	C. 10 grams (90% enrichment)
D. Uranium	D. Enriched uranium contained in foils or as oxide pellets	D. 10 grams
E. Uranium	E. Uranium metal encapsulated in aluminum cans	E. 2,550 kilograms

6. Authorized Use

A. Encapsulated neutron sources to be used in conjunction with a subcritical assembly or for other laboratory experiments requiring neutrons or for instrument calibration.

B. As alpha standards for calibration of instruments.

C. Plated sources in fission detectors for measuring neutron flux.

D. Laboratory analysis of irradiated samples and/or measurement of neutron flux.

E. As fuel in a subcritical assembly for instructional purposes.

7. Activities will be carried out by or under the supervision of the following personnel:

R. J. Cashwell (B.S. Nuclear Engineering). Experience since 1958 in the use of radiation and radioactive materials. Formerly University Health Physicist, presently Director of University of Wisconsin Nuclear Reactor, Licensed Senior Reactor Operator.

R. R. Radtke (M.P.H.-Radiological Health). Director of Safety Department, University of Wisconsin, formerly Health Physicist.

W. F. Vogelsang(PhD. Physics). Experience since 1955 in operation of reactors and critical experiments, neutron diffraction, and teaching Nuclear Engineering laboratories, Senior Reactor Operator.

Susan J. Engelhardt professional Health Physicist since 1978, currently University of Wisconsin Health Physics Supervisor.

Stephen M. Matusewic (M.S. Fine Arts). Six years navy operating experience, handling radioactive materials since 1966 as an operator and Senior Reactor Operator at the University of Wisconsin Nuclear Reactor, licensed Senior Reactor Operator.

CONTROL NO. 8556 1

8. All individuals using radioactive material on campus (excepting students in departmental laboratory courses) must be trained in material covered in the attached "Radiation Safety for Laboratory Technicians" and must pass a written examination on the subject matter. Students in laboratory courses of the Department of Nuclear Engineering and Engineering Physics have had training in radiation safety subjects and are further trained per the attached outline "Student Laboratory Orientation" The smaller scope of the training of the laboratory students is justified by their formal academic training and by the fact that they do not deal with materials in chemical and physical forms that are likely to become internal body burdens.

9. Equipment and procedures to be used with materials:

   A. All work with radiation or radioactive materials on the university campus must comply with the current version of "Radiation Safety Regulations" as approved by the University Radiation Safety Committee. Procedures, dose limits, and applicable state and federal regulations are reflected in this document (most recent copy attached). Information on disposal of radioactive material and personnel monitoring is contained in the "Radiation Safety Regulations". Sealed sources are leak tested semi-annually and alpha emitting sources are leak tested quarterly in a manner capable of detecting less than 0.005 microcuries of removable activity.

   B. Pu-Be sources are stored in metal drums filled with paraffin or other moderating material in sufficient thickness to provide personnel protection. Sources are handled with tongs or special source handling rods which screw into the source body. Portable neutron survey meters ("Snoopy", Eberline PNR-4 and BF-3 types) are available as are numerous beta-gamma survey meters.

   C. Plutonium alpha sources are stored in closed containers which will contain any leakage. The sources are designed to enable handling without touching the active surface. Alpha survey instruments are available.

   D. Fission counters are encapsulated by the outer can of the detector.

   E. Dissolution or chemical treatment of material will be carried out in fume hoods with appropriate filters and monitors to insure compliance with University Radiation Safety Regulations. Mechanical processing of the materials will take place in processing equipment so constructed as to contain and/or prevent the spread of Special Nuclear Material. The material will be stored in closed shielded containers when not involved in the processes.

   F. The natural uranium slugs are stored in water in the sub-critical assembly. The assembly is shielded by seven inches of water on the sides and five inches above. It sits on a concrete floor. Up to three Pu-Be sources are located within the assembly. Neutron fluxes at the tank surfaces are less than five neutrons/cm^2/sec. Gamma flux is less than fifty photons/cm^2/sec.

10. The Radiation Safety Program is described in the University of Wisconsin "Radiation Safety Regulations" as currently approved by the University Radiation Safety Committee. The program is reviewed and changed from time-to-time, so changes are likely to occur over the life of the license.

11. Waste Management is described in section XIX of the "Radiation Safety Regulations". Insignificant quantities of waste are generated by activities under this license.

August, 1981

STUDENT LABORATORY ORIENTATION HANDOUT

1. EVACUATION PROCEDURE

The evacuation alarm consists of continuous horns and flashing lights. If you hear the alarm, evacuate immediately to Mechanical Engineering Building Lobby or point more distant from the Reactor Laboratory. Do not take route that will get you closer to the Reactor Laboratory.

Do not re-enter area until given all-clear signal by reactor operation staff member.

2. RADIOACTIVE MATERIAL HANDLING

You will be handling sealed sources, alpha sources, and material irradiated in the reactor.

A. Always wear personnel dosimetry equipment provided on front of body, between waist and neck.

B. Always survey any item other than the small check sources stored in the Counting Laboratories.

C. Do not touch surface of alpha sources or foil surface of beta sources.

D. Always handle irradiation foils with tweezer.

E. Any sample irradiated in the reactor must be assumed to be contaminated.

Always (1) Wear gloves,
(2) Wash hands afterwards,
(3) Survey hands and report to lab instructor or reactor staff if contamination is found.

F. Never place radioactive material in regular trash cans. Specially marked stainless steel cans are available for radioactive waste disposal. ALWAYS consult instructor before disposing of radioactive material.

G. No smoking, eating, or drinking in any areas where radioactive material is scored or used.

H. You should wash hands before leaving laboratory areas. Leave personnel dosimeters in racks provided.

I. Although the Nuclear Engineering Department has made extensive efforts to prevent your exposure to hazardous materials, radiation safety precautions are stressed as part of your training.

J. Special instructions regarding radiation exposure to females are contained in Regulatory Guide 8.13. Ask your instructor for a copy of this guide to read.

K. Radiation exposure records are posted on the Reactor Laboratory bulletin board and you may obtain information on your radiation exposure upon request.

3. SECURITY

A. All areas containing radioactive material must be locked if not occupied by persons familiar with radiation safety.

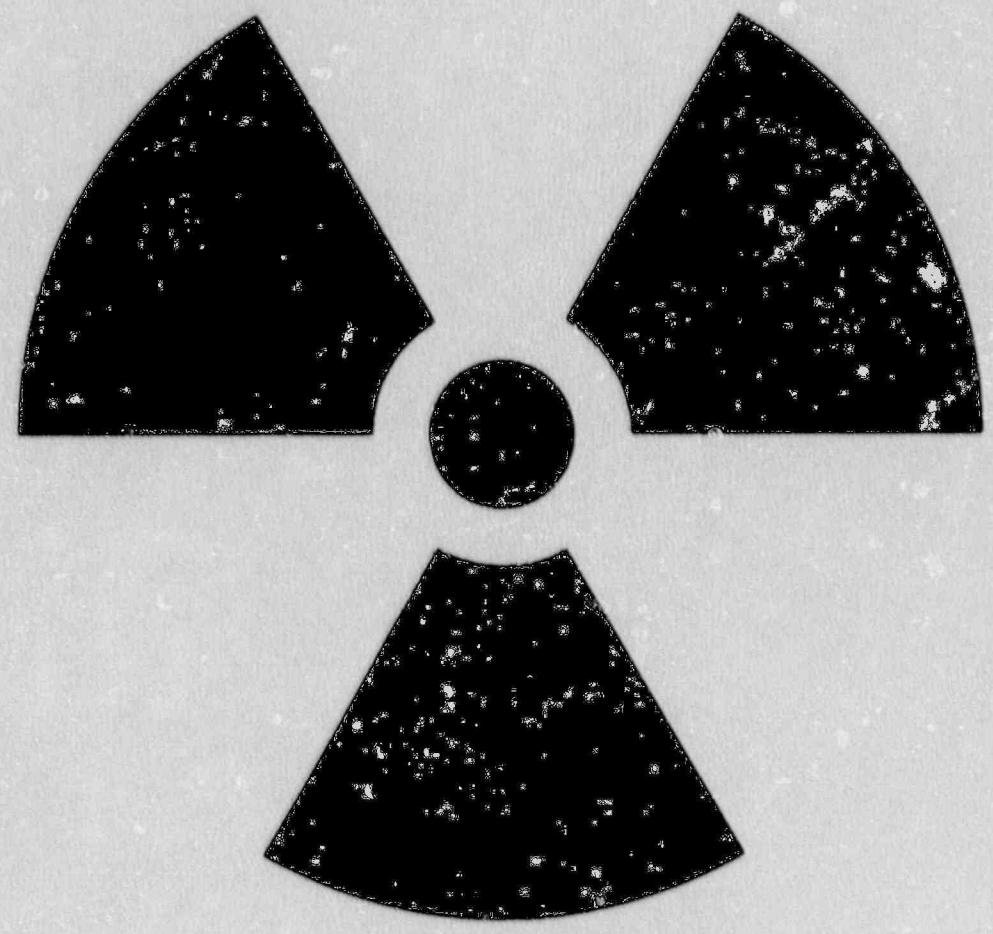
B. The Reactor Laboratory is a highly restricted area. You must be accompanied by your instructor or reactor staff to remain in the area. DO NOT BLOCK OPEN DOOR OR ATTEMPT TO DEFEAT LOCKS.

C. Do not attempt to operate or adjust equipment except on laboratory set-ups under direction of laboratory instructor or reactor operating staff.

D. Always report any condition you feel is potentially unsafe to your instructor or the Reactor Supervisor.

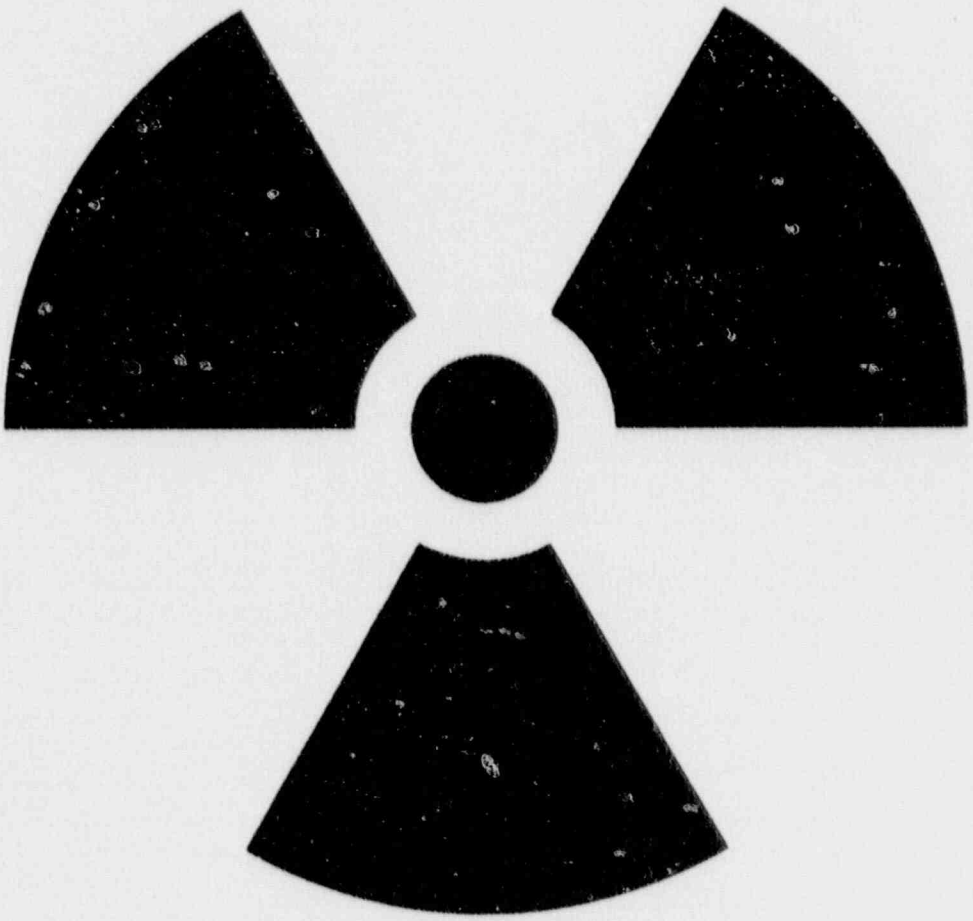
E. Refer any questions on radiation safety to instructor or laboratory staff.

RADIATION SAFETY FOR LABORATORY TECHNICIANS



UNIVERSITY
of
WISCONSIN

RADIATION SAFETY FOR LABORATORY TECHNICIANS



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RADIATION SAFETY
FOR
LABORATORY TECHNICIANS

Information Sheet to accompany

The booklet "Radiation Safety for Laboratory Technicians" is written for laboratory technicians, students and other persons who work with tracer amounts of radionuclides. Anyone working in a laboratory containing more than a minimum amount of activity (Table II, page 2) should receive instruction in the nature, detection and biological hazards of radioactivity; the steps which can be taken to reduce radiation exposure and have an awareness of current regulations regarding radioactive materials. In some cases principles have been simplified and rules summarized for easier understanding, but the basic facts are correct. As an example, the more common term "radioisotope" is used throughout the booklet instead of the less familiar but more correct term "radionuclide."

The questions at the end of each chapter are an integral part of the booklet. They check on the level of understanding which has been achieved. At the end of the book there is another series of questions designed to be removed and kept on file. The completed answer sheet will demonstrate the extent of instruction and depth of understanding of the material by each technician. All workers should review this material and be retested at least once every three years.

TABLE OF CONTENTS

PREFACE TO THE READER

Every person working with radioisotopes should know something about them and their effects. Table I lists the topics covered in this booklet.

Table I

Required Knowledge for Persons Working With Radioisotopes

1. Nature and Characteristics of Radiation and Radioactivity.
2. Radiation Detection.
3. Possible Hazards of Radiation Including Hazards to the Fetus.
4. Safety Practices Which Can Reduce Radiation Exposure to Workers and the Environment.
5. What to Do If Something Goes Wrong.
6. Current Regulations and License Provisions.

Anyone issued a film badge or working in a room containing amounts of radioactivity greater than those listed in Table II should receive adequate instruction in these topics.

The required depth and extent of knowledge depends on the amount, type, and chemical form of radioisotopes a person works with, and the hazards associated with the radioactivity. Each individual is responsible for clarifying any questions regarding his working conditions. A person cannot be fired or discriminated against for asking questions about radiation safety procedures. The phone number of the Radiation Safety Officer is 262-8769. You don't need the permission of anyone to call this office or to ask questions.

Every person working with radioactive material has the right to inspect the current applicable regulations and a copy of the current license. Each laboratory should have a copy of University rules and regulations and the operating procedures which are also available for inspection. Every person who wears a film badge has the right to request the record of their annual exposure.

The glossary in the back of the book will explain any new words used in the text. The questions at the end of the each chapter are designed to help you decide whether or not you understand the material in the chapter. If you are not sure of the correct answer, look back in the chapter before answering the question. Be sure you can answer all the questions correctly before going on to the next chapter. The correct answers are given in the back of the book.

At the end of the booklet there is a final group of questions covering all the material. If you don't know the answer to one of the final questions, look it up in the proper chapter. After you have answered all of the questions, tear out the sheet and turn it in to your supervisor. You should be able to answer all of the questions correctly.

If you routinely work with more than one millicurie of radioactivity or if you supervise other workers using radioisotopes, then you must have a more thorough understanding of radiation protection and safety than you can obtain from this book alone. Contact your supervisor or the Health Physics staff for more complete instruction and background materials.

Table II

Persons working in rooms containing more than these amounts of radioisotopes should receive additional instruction.

Isotope	*Amount (microcuries)*
Tritium	10,000
Carbon-14	1000
Sodium-22	10
Sodium-24	100
Phosphorus-32	100
Sulphur-35	1000
Calcium-45	100
Chromium-51	10,000
Cobalt-57	10
Cobalt-60	10
Nickel-63	100
Zinc-65	100
Selenium-75	100
Technetium-99m	1000
Iodine-125	10
Cesium-137	100

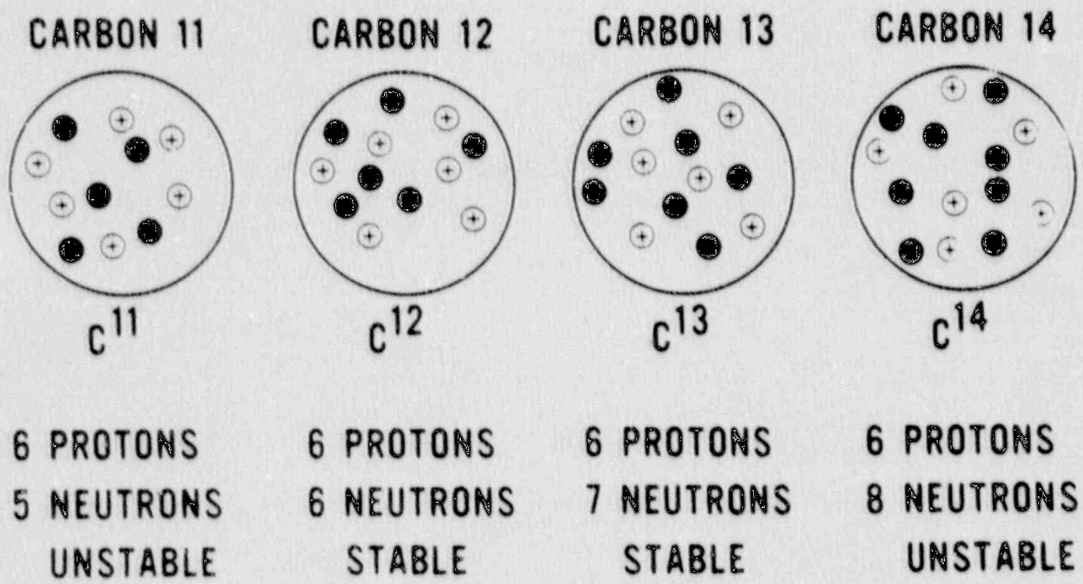
Chapter I

Radiation and Radioisotopes

Chapter 1 - Radiation and Radioisotopes

Radioactivity is the name we give to the natural breakup of atoms. Atoms are made up of a dense positive core called the *nucleus* which is surrounded by electrons. The nucleus contains protons which carry a positive charge and neutrons which are as heavy as protons, but have zero charge. Electrons are very light and have a negative charge.

The chemical properties of an atom are determined by the number of protons in the nucleus. For example, every atom which has six protons in its nucleus is a carbon atom. Different numbers of neutrons may exist in a carbon nucleus; there can be five, six or seven or eight. Each of these atoms is a different *isotope* of carbon. Figure 1 illustrates the isotopes of carbon. All elements have isotopes. Some isotopes are stable and some are unstable. An unstable isotope has too many protons or too many neutrons in its nucleus. To get rid of the excess the nucleus decays to a different nucleus by throwing out (emitting) particles and energy. This is the property we call *radioactivity*. There is no way to alter the decay of a radioisotope. To *activate* materials means to make them radioactive. This can be done by putting the material in a nuclear reactor. If something touches a radioisotope, it may become contaminated with radioactive material (see Chapter 6), but it doesn't become radioactive.



ISOTOPES OF CARBON

Figure 1

Every radioisotope has three important properties:

1. Emitted particles
2. Particle energy
3. Half-life

Particles

When a radioisotope decays, it may give off an alpha particle, a beta particle or a gamma ray. Table III presents the properties of these three decay particles.

Table III

Name	*Symbol*	*Properties*
Alpha Particle	α	Short range—easy to shield
Beta Particle (or beta ray)	β	Moderate penetration—possible to shield
Gamma Rays (photons)	γ	Very penetrating—difficult to shield against

Alpha particles have two positive charges and a very short range. This means that they are not usually a biological hazard unless they get inside the body. Beta particles are fast electrons with a single charge. Low-energy beta particles are easy to shield against and are a hazard only if they are inside the body. Higher-energy beta particles have greater penetration and can be a hazard even if they are outside the body. Gamma rays are similar to visible light but have higher energy. They are very penetrating and should always be considered a hazard to the body.

Energy

The energy and kind of a decay particle determines its penetration, and how much shielding will be required. Decay energy is given in kiloelectron volts (keV) or million-electron volts (MeV). An electron volt is a unit of energy. Higher-energy particles are more penetrating. Gamma rays need more shielding than alpha or beta particles.

Half-life

Radioisotopes are always decaying so the amount remaining is continually decreasing. The half-life describes how fast the decay is taking place (rate of decay). The half-life ($T_{\frac{1}{2}}$) is the time required for the amount of radioisotope to decrease to half its original amount. Figure 2 shows a plot of the decay of a radioisotope having a half-life of 1 day. We have plotted the amount of radioisotope left after 1, 2, 3, etc. days so that you can see how rapidly the amount decreases.

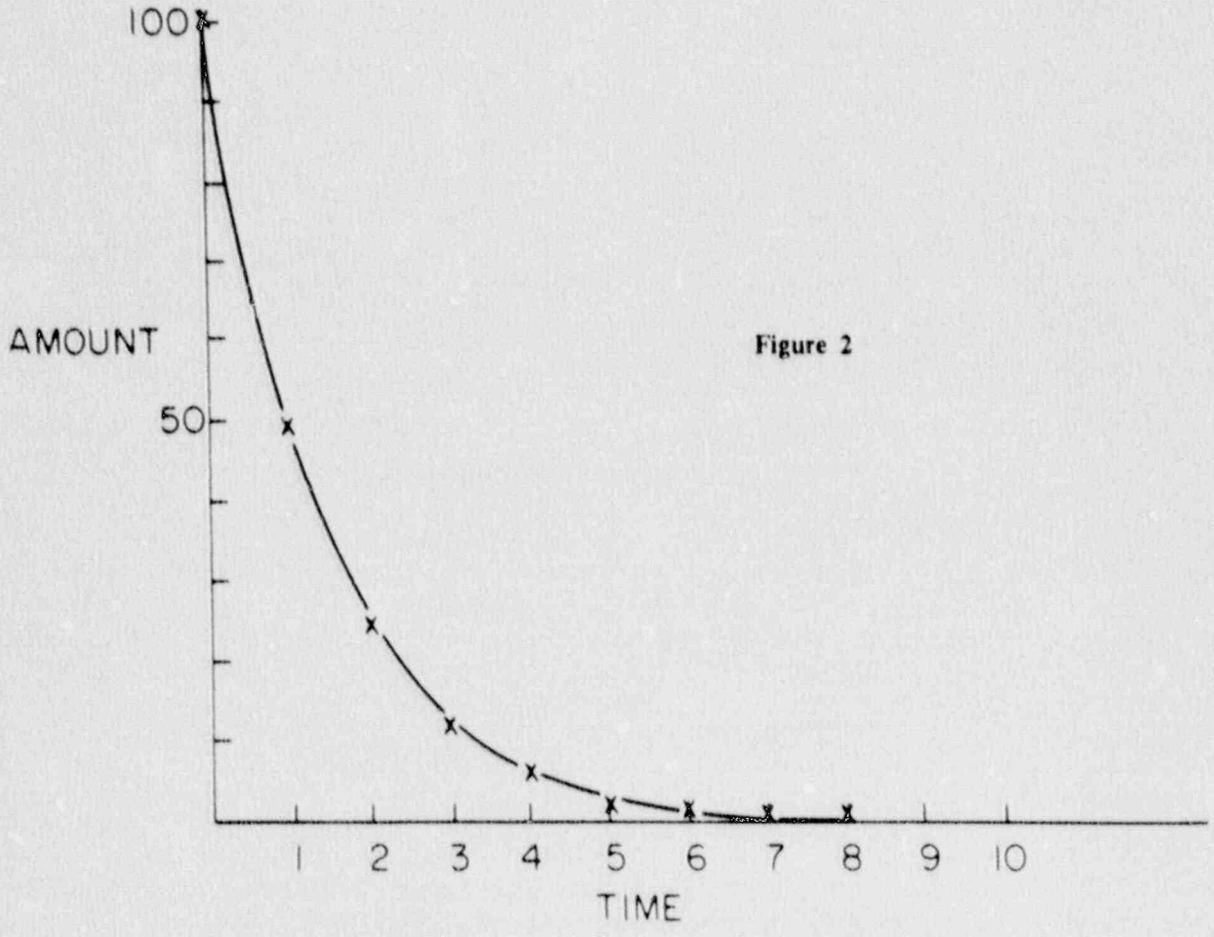


Figure 2

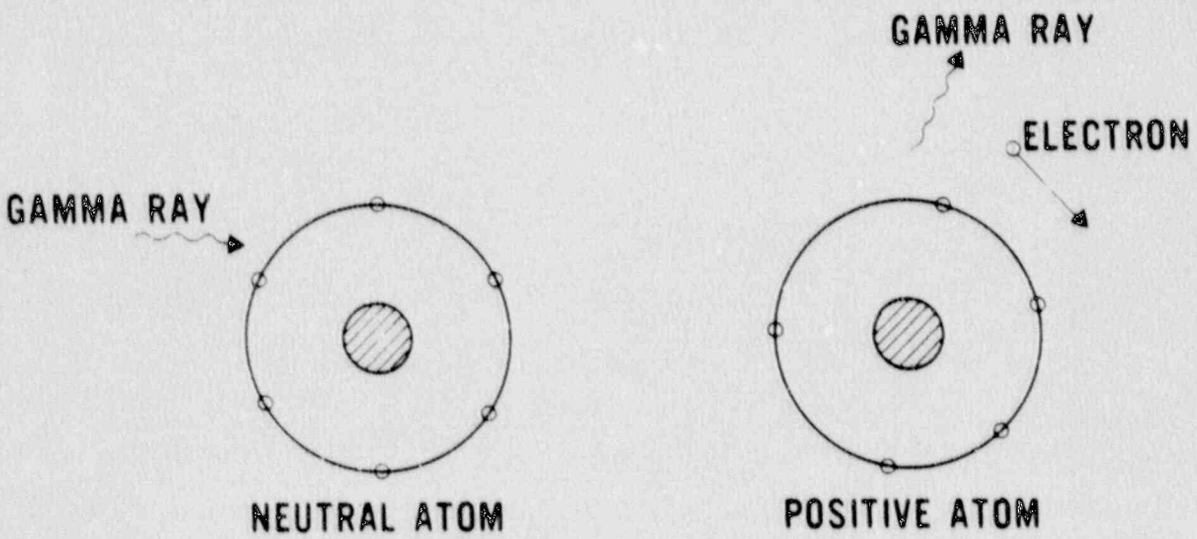
Activity

The amount of radioactive material is measured by how many nuclei decay each second. This is called the activity and is measured in units of curies. The abbreviation for curie is Ci. One curie represents 37 billion disintegrations (decays) per second (3.7×10^{10}dps). A millicurie (mCi) is 1/1,000 of a curie and a microcurie (μCi) is one millionth part of a curie. Referring to Figure 2, if we start with 100 microcuries of material, by the end of the second day we will have only 25 microcuries and at the end of the fourth day there will only be 6.25 microcuries. This still means there are over one quarter million disintegrations per second, even after four half-lives.

Roentgens, Rads, and Rems

When alpha, beta or gamma radiation passes through matter, it forms ions by knocking electrons loose from their atoms. This separation of electrons from their atoms is called *ionization* and is illustrated in Figure 3. Ionization makes X and gamma rays different from other electromagnetic radiations such as light rays or radio waves. We use the ionization to measure X rays by collecting all the ions formed in a volume of air. When you collect one electrostatic unit (e.s.u.) of charge in a chamber which contains 1 gram of dry air, you know that 1 roentgen has passed through the chamber. Thus the roentgen is a measure of ionization in air. This is the definition of the roentgen. It is a fairly large unit so we often divide the roentgen into units of milliroentgen (mR) which correspond to 1/1,000 of a roentgen.

The rad is a unit of absorbed dose and equals 100 ergs deposited in one gram of matter. Although the roentgen is a unit of radiation exposure in air while the rad is a unit of exposure in tissue, the two units are very close in magnitude. In fact, 1 roentgen produces 0.96 rad in tissue.



IONIZATION

Figure 3

The rem is a unit of radiation dose used in radiation safety to equalize various kinds of irradiation. When rads are multiplied by a quality factor (QF), which can vary from 1 to 20, the result is rem. In most cases absorbed doses in rads and the dose equivalent in rems are numerically equal.

Table IV

Common Radioisotopes

Isotope	*Symbol*	*Half-life*	*Principle Decay Products*	*Characteristic Energy (keV)*
Tritium	H-3	12.6 yrs.	β	6
Carbon-14	C-14	5700 yrs.	β	50
Sodium-22	Na-22	2.6 yrs.	γ	510, 1275
Sodium-24	Na-24	15 hrs.	γ	1370, 2750
Phosphorus-32	P-32	14 days	β	690
Sulfur-35	S-35	88 days	β	50
Calcium-45	Ca-45	165 days	β	75
Chromium-51	Cr-51	28 days	γ	320
Cobalt-57	Co-57	270 days	γ	122
Cobalt-60	Co-60	5 yrs.	γ	1300
Nickel-63	Ni-63	92 yrs.	β	20
Zinc-65	Zn-65	245 days	γ	1100
Selenium-75	Se-75	120 days	γ	270
Technetium-99m	Tc-99m	6 hrs.	γ	140
Iodine-125	I-125	60 days	γ	35
Iodine-131	I-131	8 days	γ	360
Cesium-137	Cs-137	30 yrs.	γ	660

Chapter 1 Fill in the Blanks

1. _____ is the name given to disintegrations of atomic nuclei.
2. Each atom is made up of a positive _____ surrounded by negative _____ .
3. Protons have a _____ charge.
4. Neutrons have a _____ charge.
5. _____ are very light.
6. An _____ has the same number of protons but different number of neutrons in the nucleus.
7. The _____ of radioisotopes cannot be changed or altered.
8. To activate materials means to make them _____ .
9. The three products of radioactive decay are _____ , _____ , and _____ .
10. _____ are the most penetrating decay product.
11. The _____ is the time required for half the material to decay away.
12. The activity of radioactive material is measured in units of _____ .
13. The amount of gamma rays present is measured in _____ .
14. The amount of energy absorbed from the radiation is measured in _____ .

Chapter II

Radiation Detectors

Chapter 2 - Radiation Detectors

Survey Meters

Most survey meters use either an ion chamber or a Geiger Mueller (GM) tube to detect ionization produced by radiation. A GM tube will detect smaller amounts of radiation than an ion chamber. Figure 4 shows a schematic circuit of a survey meter. The radiation produces ionization inside the detector tube. Electrons liberated by the radiation are attracted to the positive center wire and positive ions move toward the negative outer shell of the detector tube. The survey meter indicates the amount of radiation present. A special thin "window" tube is needed to detect beta particles because the range of beta particles is so short they can't get inside a tube with normally thick walls. The energy of beta particles from tritium is so low they can't get into even a thin window tube. *Tritium cannot be detected with a portable survey meter.* Therefore wipe tests are used to monitor for tritium (see page 32).

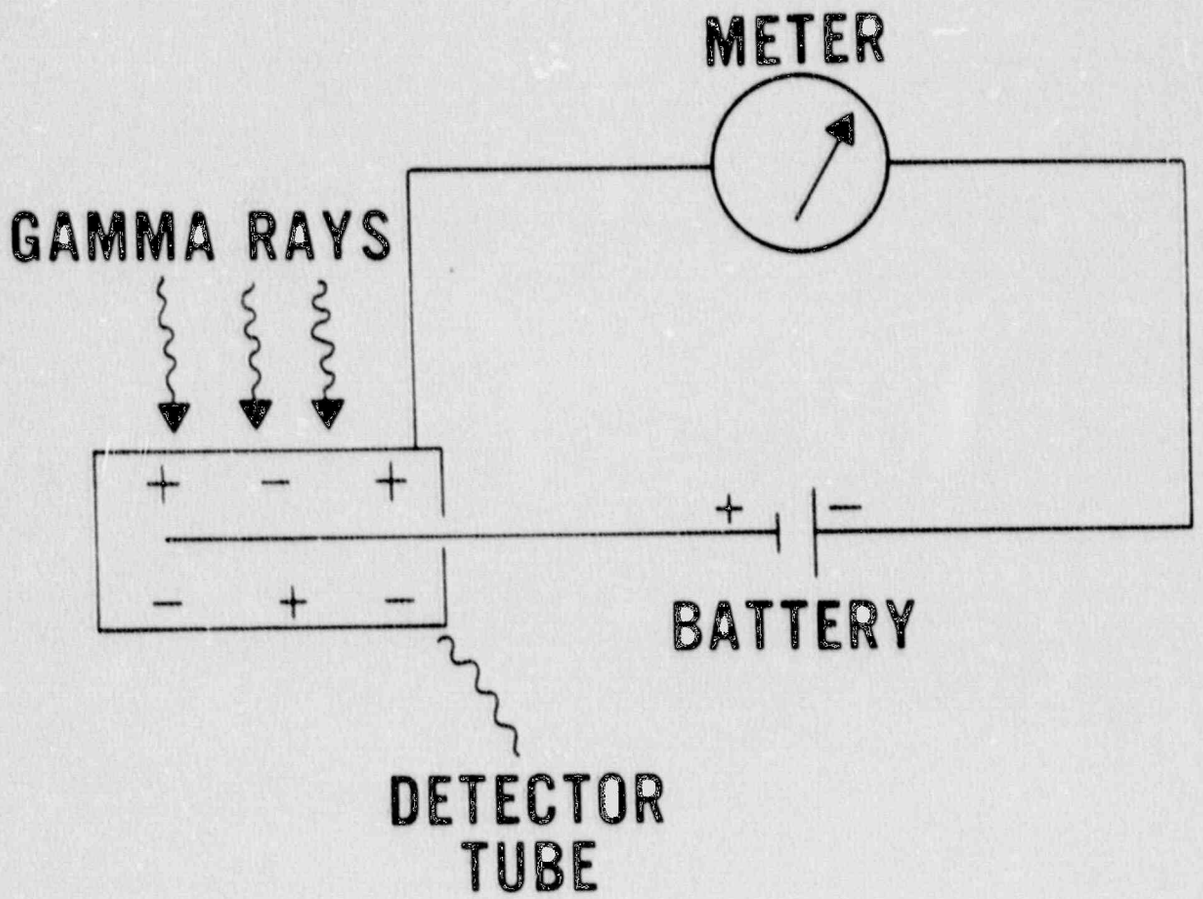
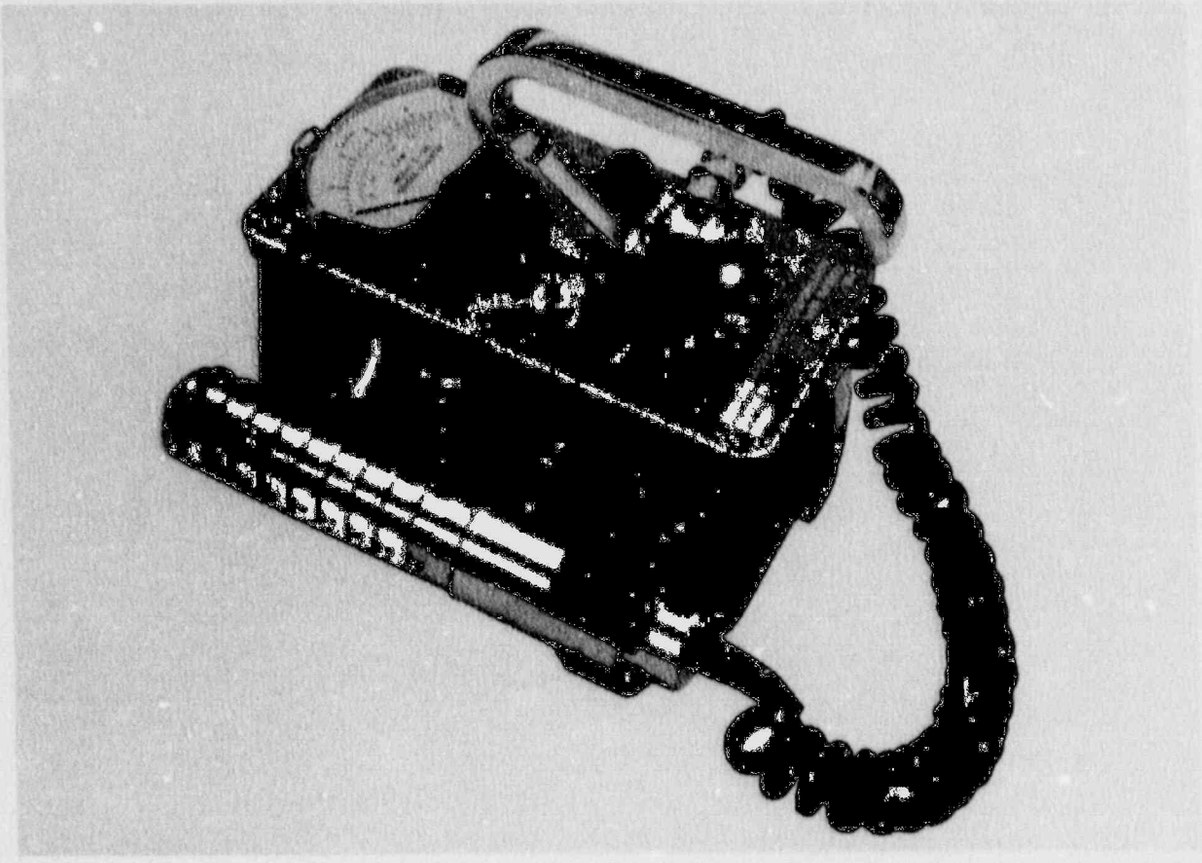


Figure 4

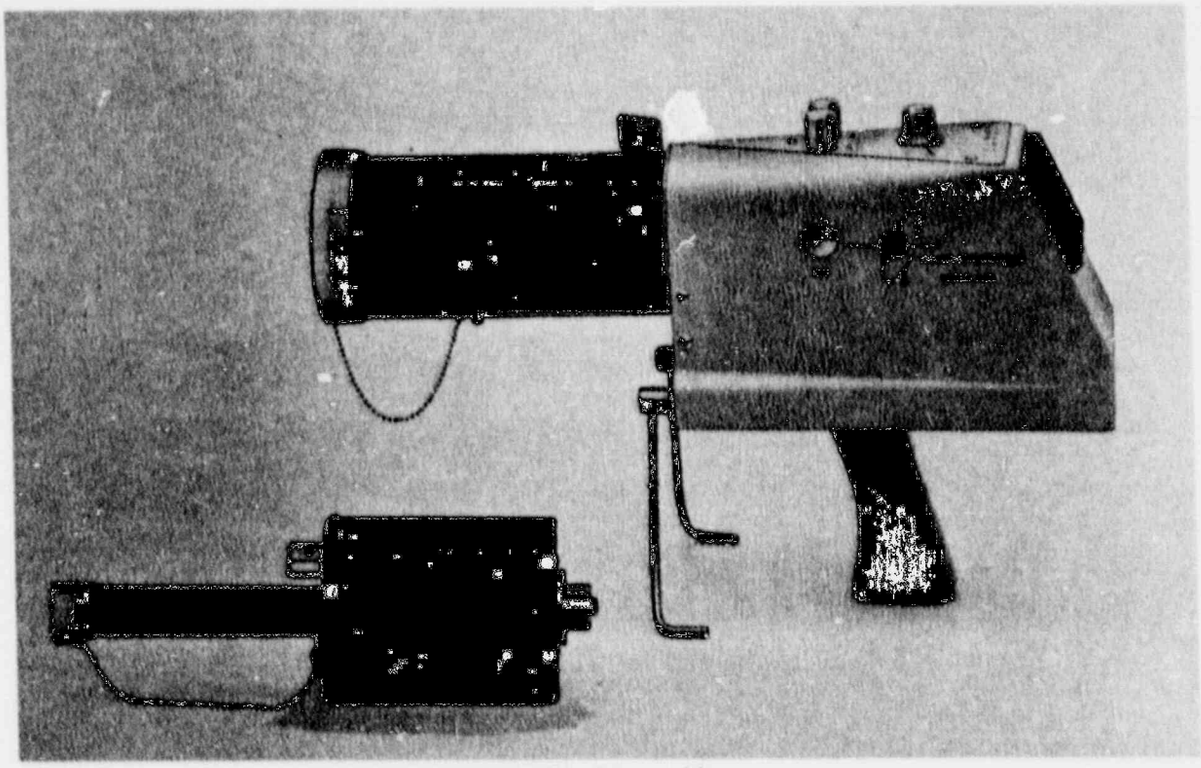
Figure 5 shows a GM and ionization chamber survey meter. Before using a survey meter always check to make sure it's working. Test the meter by exposing it to a known source of radiation. If nothing registers, have the instrument repaired and the calibration checked.

Cutie Pie Survey Meter



GM Survey Meter

Figure 5



Cutie Pie Survey Meter

GM Survey Meter

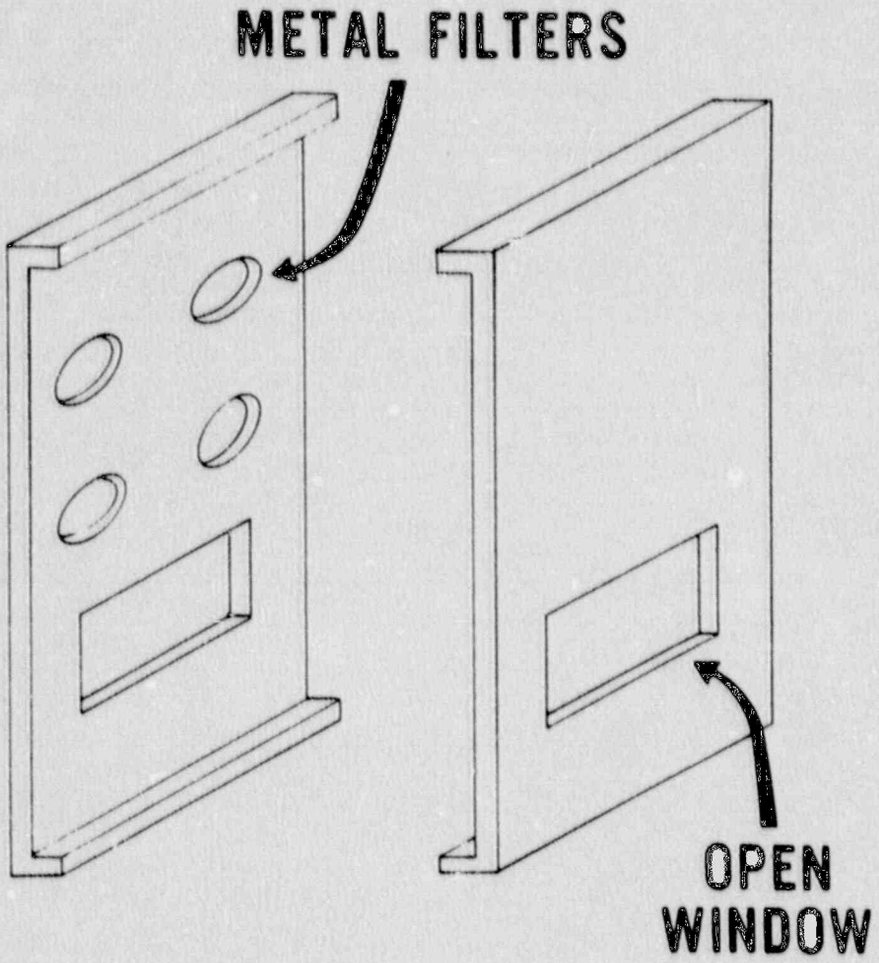
Figure 5

Scintillators

A *scintillator* is a material which gives off a flash of light when struck by radiation. Solid scintillators like sodium iodide crystals are used in nuclear medicine departments to determine the radiation from the distribution of radioisotopes in patients. Liquid scintillators are used to detect beta particles and low-energy gamma rays. Betas from the decay of tritium have such low energy they cannot penetrate the walls of counter tubes. By mixing a tritiated solution with a scintillation liquid, we can detect the betas from tritium. Liquid scintillators detect all beta energies very well but don't do a good job of detecting high-energy gamma rays.

Film Badges

X rays and beta particles can darken film just as well as visible light. This property is the basis for the common film badge. Figure 6 shows an exploded view of a film badge holder. Several different designs are available but they all have essentially the same components. A piece of film wrapped in paper is inserted in the plastic holder. An open window in the plastic passes low-energy betas which could not penetrate the plastic holder. Tritium betas are so weak they cannot even penetrate the paper wrapper of the film. Small pieces of aluminum, copper and lead are molded in the plastic holder to act as filters. Gamma rays that get through the aluminum may be stopped by the copper or the lead. When the film is developed, different areas of blackness appear under the different metals. The film badge company can analyze the darkness patterns to determine both the type and amount of radiation which has exposed the badge. Everyone who may be exposed to significant amounts of gamma rays or high-energy betas is issued a film badge. The film badge records the amount of radiation that strikes it. The badge should be worn at waist or chest level to record the dose to the whole body. If a protective apron is worn, the badge should be worn on the collar outside the apron. Persons working with only minute amounts of radioactivity, ^{14}C or tritium, need not wear a film badge.



SCHEMATIC VIEW OF
FILM BADGE HOLDER

Figure 6

Chapter 2

1. The separation of electrons from atoms is called _____ .
2. X and gamma rays can produce _____ .
3. A _____ is more sensitive than an ion chamber.
4. Tritium beta particles cannot be detected with a portable _____ .
5. Tritium beta particles can be detected with _____ .
6. Film badges are used to monitor the radiation _____ .
7. Persons working with tritium do not need to wear a _____ .
8. When a protection apron is worn, the film badge should be worn _____ _____ _____ .

Chapter III

Biological Effects of Radiation

Chapter 3 - Biological Effects of Radiation

Radiation effects on humans can be divided into *somatic* and *genetic* effects. Some somatic effects will show up during a person's lifetime; genetic effects are passed on to future generations. The nature of the hazards from radioisotopes depends strongly on whether the isotope is inside (internal) or outside (external) the body. Only gamma or high-energy beta emitters are external hazards. All radioisotopes are hazardous when they get inside the body. Table V lists the common radioisotopes which are *not* a hazard as long as they are kept outside the body. They emit low-energy beta particles which cannot penetrate the skin.

Table V

Common Low-Energy Beta Emitters Which Are Not a Hazard Outside the Body

Isotope	*Symbol*	*Half-Life*	*Decay Product*	*Average Energy (keV)*
Tritium	H-3	12.6 yrs.	β	6
Carbon-14	C-14	5700 yrs.	β	50
Sulfur-35	S-35	88 days	β	50
Nickel-63	Ni-63	92 yrs.	β	20

Radioisotopes can get into the body during eating, drinking, breathing or especially through the skin. Some of the radioisotope which enters the body is excreted, but some may also be incorporated into body tissues. If the isotope is excreted rapidly, the hazard is less than if it remains inside for a long time as part of the body tissue. The biological half-life measures how long it takes for half the original isotope to be excreted from the body if the isotope were not radioactive. Specific organs may have different biological half-lives. All the time the radioisotope is in the body it is also decaying so that even if none of the isotope is excreted, the amount in the body is still continually decreasing. The combination of biological half-life and radioisotope half-life (the physical half-life) is called "effective half-life."

Table VI gives the physical, biological and effective half-lives of some of the common radioisotopes. The value listed as biological half-life is the whole body half-life.

The body can repair some of the damage caused by radiation. The effects of radiation may show up as an increased incidence of cancer, leukemia and a general life shortening.

Table VI

Biological Half-Life

Isotope	*Physical Half-Life Days*	*Biological Half-Life Days*	*Effective Half-Life Days*
H-3	4.5×10^3	12	12
C-14	2×10^6	10	10
Na-22	950	11	11
P-32	14.3	257	13.5
S-35	87.1	90	44.3
Ca-45	164	1.64×10^4	162
Cr-51	27.8	616	26.6
Co-57	270	9.5	9.2
Rb-86	18.6	45	13.2
I-125	60	138	42
I-131	8.05	138	7.6

From: *Handbook of Radioactive Nuclides*
Yen Wang, M.D., D.Sc.
Chemical Rubber Company, 1969

Irradiation During Pregnancy

The fetus is especially sensitive to radiation during the first three months of pregnancy when most organ development is taking place.

It has been recommended that the radiation dose to an embryo or fetus as a result of occupational exposure of the expectant mother should not exceed 0.5 rem because of possible detrimental effects. Since this 0.5 rem is lower than the dose generally permitted to adult workers, women may want to take special actions to avoid receiving higher exposures. (See Regulatory Guide 8.13, end of chapter.)

Genetic Effects

Ionization can produce genetic effects by damaging the *chromosomes* in the cell nucleus. This chromosome damage can produce *mutations* in subsequent generations. Most mutations are harmful. Chromosome damage is continually occurring throughout our lives due to background radiation and other mutagenic agents such as chemicals and pollutants. *Background radiation* is radiation which is always present. It comes from natural radioactivity in the rocks and soil and from cosmic rays. There is even some natural radioactivity in every living body. A chromosome mutation may have occurred many, many generations ago or the day before conception. There is no way to know. *Mutations* are carried through succeeding generations by the genes. Radiation of persons beyond childbearing age will have no genetic effect on future populations because they cannot pass on damaged chromosomes to their children.

Biological Hazards of Tritium Compounds

The hazard from tritium is less than from other radioisotopes because the tritium betas have such low energy and because tritiated water is excreted from the body very quickly. Tritiated water is absorbed both through the lungs and the pores of the skin with equal efficiency. It quickly (20 minutes) disperses itself throughout the body water and is excreted with a biological half-life of about 10 days. Tritiated compounds can readily pass through the placenta to the developing fetus. The potential hazard to the fetus is greater than to the mother because fetal tissue is rapidly growing and very sensitive to radiation.

Tritiated Thymidine and Other DNA Precursors

Tritiated DNA precursors are a special case because they are used by the body for building new cells and hence are much more hazardous. Once in the cellular structure, they are excreted very slowly. Half the tritiated thymidine entering the body is converted to tritiated water and excreted with a 10-day half-life. The rest is incorporated into the cellular DNA with a half-life of about 1 year. For this reason tritiated DNA precursors are more hazardous than other tritiated compounds. All DNA precursors should be treated as hazardous or toxic compounds. They are no hazard as long as they remain outside the body. Good housekeeping and cleanliness are essential. NEVER MOUTH PIPETTE ANY RADIOACTIVE SOLUTION.

Chapter 3

1. _____ effects show up during a person's lifetime.
2. _____ effects are passed on to future generations.
3. Tritium and carbon-14 compounds are hazardous only if they are _____ the body.
4. Biological half-life measures how long it takes for _____ the original amount of isotope to be _____ from the body.
5. Isotopes with short biological half-life are a _____ hazard than those with long biological half-life.
6. The fetus is especially sensitive to radiation during the _____ three months of pregnancy.
7. Women who are pregnant should not be exposed to more than _____ mR during their pregnancy.
8. Chromosome damage can produce harmful _____ .
9. Tritiated DNA precursors are especially _____ .
10. Low-energy beta emitters are a biological hazard only if they are _____ the body.
11. _____ _____ are always a hazard, even outside the body.

U.S. NUCLEAR REGULATORY COMMISSION

November 1975
Revision 1

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 8.13 ... T OF SAFETY

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12 of 10 CFR Part 19 states that all individuals working in or frequenting any portion of a restricted area must be instructed in the health protection problems associated with exposure to radioactive materials or radiation. This guide describes the instruction that should be provided concerning biological risks to embryos or fetuses resulting from prenatal exposure.*

B. DISCUSSION

Since the Law of Bergonie and Tribondeau was published in 1906** it has been known that the sensitivity of cells to radiation damage is related to their reproductive activity and inversely related to their degree of differentiation. It follows that children could be expected to be more radiosensitive than adults, fetuses more radiosensitive than children, and embryos even more radiosensitive.

This principle has long been a factor in the development of radiation exposure standards. Section 20.104 of 10 CFR Part 20 places different limits on minors than on adult workers. Specifically, it limits anyone under the age of 18 to exposures not exceeding 10% of the limits for adult workers. However, §20.104 does not relate to embryos or fetuses.

A special situation arises when an occupationally exposed woman is pregnant. Exposure of the abdomen of such a worker to penetrating radiation from either external or internal sources would also involve exposure of the embryo or fetus. Because a number of studies have indicated that the embryo or fetus is more sensitive than an adult, particularly during the first three months after conception, when a woman may not be aware that she is pregnant, the National Council on Radiation Protection and Measurements (NCRP) recommended in its Report No. 39 that special precautions be taken to limit exposure when an occupationally exposed woman could be pregnant.

C. REGULATORY POSITION

Instruction to workers performed under §19.12 should be given prior to assignment to work in a restricted area. In providing instruction about health protection problems associated with radiation exposure, female workers and those who may supervise or work with them should be given specific instruction about prenatal exposure risks to the developing embryo and fetus.

The instruction should ensure that the employees understand:

1. That the NCRP has recommended that, during the entire gestation period, the maximum permissible dose equivalent to the fetus from occupational exposure of the expectant mother should not exceed 0.5 rem and

2. The reasons for this recommendation.

The instruction should include the information provided in the Appendix to this guide. It should be presented to the employee, her supervisors, and her co-workers both orally and in written form. Each individual should be given an opportunity to ask questions, and each individual should be asked to acknowledge in writing that the instruction has been received.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees regarding the use of this guide.

*This revision of the guide includes minor changes of a clarifying nature incorporated as a result of public comments. No substantive changes have been made.

**_Comptes Rendus des Seances de l'Academie des Sciences_, Vol. 143, pp. 983-985, 1906.

Except in those cases in which the licensee chooses to propose an alternative method for complying with the portion of the Commission's regulations previously specified, the methods described herein should be used immediately to instruct female employees working in or frequenting any portion of a restricted area, and those who may supervise or work with such employees, concerning the health protection problems associated with prenatal radiation exposure.

APPENDIX TO REGULATORY GUIDE 8.13

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

Some recent studies have shown that the risk of leukemia and other cancers in children increases if the mother is exposed to a significant amount of radiation during pregnancy. According to a report by the National Academy of Sciences, the incidence of leukemia among children from birth to 10 years of age in the United States could rise from 3.7 cases in 10,000 children to 5.6 cases in 10,000 children if the children were exposed to 1 rem of radiation before birth (a "rem" is a measure of radiation). The Academy has also estimated that an equal number of other types of cancers could result from this level of radiation. Although other scientific studies have shown a much smaller effect from radiation, the Nuclear Regulatory Commission wants women employees of its licensees to be aware of any possible risk so that the women can take steps they think appropriate to protect their offspring.

As an employee of a Nuclear Regulatory Commission licensee, you may be exposed to more radiation than the general public. However, the Nuclear Regulatory Commission has established a basic exposure limit for all occupationally exposed adults of 1.25 rems per calendar quarter or 5 rems per year. No clinical evidence of harm would be expected in an adult working within these levels for a lifetime. Because the risks of undesirable effects may be greater for young people, individuals under 18 years of age are permitted to be exposed to only 10 percent of the adult occupational limits. (This lower limit is also applied to members of the general public.)

The scientific organization called the National Council on Radiation Protection and Measurements has recommended that because unborn babies may be more sensitive to radiation than adults, their radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem. Other scientific groups, including the International Commission on Radiation Protection, have also stressed the need to keep radiation doses to unborn children as low as is reasonably achievable.

All Nuclear Regulatory Commission licensees are now required* to inform all individuals who work in a restricted area of the health protection problems associated with radiation exposure. This instruction would in many cases include information on the possible risks to unborn babies. The regulations also state** that licensees should keep radiation exposures as low as is reasonably achievable. According to the National Council on Radiation Protection and Measurements, vigorous efforts should be made to keep the radiation exposure of an embryo or fetus at the very lowest practicable level during the entire period of pregnancy.

Thus it is the responsibility of your employer to take all practicable steps to reduce your radiation exposure. Then it is your responsibility to decide whether the exposure you are receiving is sufficiently low to protect your unborn child. The advice of your employer's health physicist or radiation protection officer should be obtained to determine whether radiation levels in your working areas are high enough that a baby could receive 0.5 rem or more before birth. If so, the alternatives that you might want to consider are:

(a) If you are now pregnant or expect to be soon, you could decide not to accept or continue assignments in these areas.

(b) You could reduce your exposure, where possible, by decreasing the amount of time you spend in the radiation area, increasing your distance from the radiation source, and using shielding.

(c) If you do become pregnant, you could ask your employer to reassign you to areas involving less exposure to radiation. If this is not possible, you might consider

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* By Title 10, Part 19 of the Code of Federal Regulations.

**In Title 10, Part 20.

leaving your job. If you decide to take such steps, do so without delay. The unborn child is most sensitive to radiation during the first three months of your pregnancy.

(d) You could delay having children until you are no longer working in an area where the radiation dose to your unborn baby could exceed 0.5 rem.

You may also, of course, choose to:

(e) Continue working in the higher radiation areas, but with full awareness that you are doing so at some small increased risk for your unborn child.

The following facts should be noted to help you make a decision:

1. The first three months of pregnancy are the most important, so you should make your decision quickly.

2. In most cases of occupational exposure, the actual dose received by the unborn baby is less than the dose received by the mother because some of the dose is absorbed by the mother's body.

3. At the present occupational exposure limit, the actual risk to the unborn baby is small, but experts disagree on the exact amount of risk.

4. There is no need to be concerned about sterility or loss of your ability to bear children. The radiation dose required to produce such effects is more than 100 times larger than the Nuclear Regulatory Commission's dose limits for adults.

5. Even if you work in an area where you receive only 0.5 rem per three-month period, in nine months you could receive 1.5 rems, and the unborn baby could receive more than 0.5 rem, the full-term limit suggested by the NCRP. Therefore, if you decide to restrict your unborn baby's exposure as recommended by the NCRP, be aware that the 0.5 rem limit to the unborn baby applies to the full nine-month pregnancy.

The remainder of this document contains a brief explanation of radiation and its effects on humans. As you will see, some radiation is present everywhere and the levels of radiation most employees of Nuclear Regulatory Commission licensees receive are not much larger than these natural levels. Because the radiation levels in the facility where you will be working are required by law to be kept quite low, there is not considered to be a significant health risk to individual adult employees.

Discussion of Radiation

The amount of radiation an individual receives is called the "dose" and is measured in "rems." The average individual in the United States accumulates a dose of one rem from natural sources every 12 years. The dose from natural radiation is higher in some states, such as Colorado, Wyoming, and South Dakota, primarily because of cosmic radiation. There the average individual gets one rem every 8 years.

Natural background radiation levels are also much higher in certain local areas. A dose of one rem may be received in some areas on the beach at Guarapari, Brazil, in only about 9 days, and some people in Kerala, India, get a dose of one rem every 5 months.

Many people receive additional radiation for medical reasons. In 1970, an estimated 212 million X-ray examinations were performed in the United States. The estimated average surface skin dose from one radiographic chest X-ray is 0.027 rem. The estimated average surface skin dose per abdominal X-ray is 0.62 rem.*

Radiation can also be received from natural sources such as rock or brick structures, from consumer products such as television and glow-in-the-dark watches, and from air travel. The possible annual dose from working 8 hours a day near a granite wall at the Redcap Stand in Grand Central Station, New York City, is 0.2 rem, and the average annual dose in the United States from TV, consumer products, and air travel is 0.0026 rem.

Radiation, like many things, can be harmful. A large dose to the whole body (such as 600 rems in one day) would probably cause death in about 30 days, but such large doses result only from rare accidents. Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some risk. The occupational exposure limits are set so low, however, that medical evidence gathered over the past 50 years indicates no clinically observable injuries to individuals due to radiation exposures when the established radiation limits are not exceeded. This was true even for exposures received under the early occupational exposure limits, which were many times higher than the present limits. Thus the risk to individuals at the occupational exposure levels is considered to be very low. However, it is impossible to say that the risk is zero. To decrease the risk still further, licensees are expected to keep actual exposures as far below the limits as is reasonably achievable.

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*"Pre-Release Report: X-Ray Exposure Study (XES) Revised Estimates of 1964 and 1970 Genetically Significant Dose," February 4, 1975, U.S. Department of Health, Education, and Welfare, Public Health Service, Federal Drug Administration, Bureau of Radiological Health.

The current exposure limits for people working with radiation have been developed and carefully reviewed by nationally and internationally recognized groups of scientists. It must be remembered, however, that these limits are for adults. Special consideration is appropriate when the individual being exposed is, or may be, an expectant mother, because the exposure of an unborn child may also be involved.

Prenatal Irradiation

The prediction that an unborn child would be more sensitive to radiation than an adult is supported by observations for relatively large doses. Large doses delivered before birth alter both physical development and behavior in experimentally exposed animals. A report of the National Academy of Sciences states that short-term doses in the range of 10 to 20 rems cause subtle changes in the nerve cells of unborn and infant rats. The report also states, however, that no radiation induced changes in development have been demonstrated to result in experimental animals from doses up to about 1 rem per day extended over a large part of the period before birth.

The National Academy of Sciences also noted that doses of 25 to 50 rems to a pregnant human may cause growth disturbances in her offspring. Such doses substantially exceed, of course, the maximum permissible occupational exposure limits.

Concern about prenatal exposure (i.e., exposure of a child while in its mother's uterus) at the permissible occupational levels is primarily based on the possibility that cancer (especially leukemia) may develop during the first 10 years of the child's life. Several studies have been performed to evaluate this risk. One study involved the followup of 77,000 children exposed to radiation before birth (because of diagnostic abdominal X-rays made for medical purposes during their mother's pregnancy). Another study involved the followup of 20,000 such children. In addition, 1292 children who received prenatal exposure during the bombing of Hiroshima and Nagasaki were studied. Although contradictory results have been obtained, most of the evidence suggests a relationship between prenatal exposure and an increased risk of childhood cancer.

Summary

Occupational exposures to radiation are being kept low. However, qualified scientists have recommended that the radiation dose to an embryo or fetus as a result of occupational exposure of the expectant mother should not exceed 0.5 rem because of possible increased risk of childhood leukemia and cancer. Since this 0.5 rem is lower than the dose generally permitted to adult workers, women may want to take special actions to avoid receiving higher exposures, just as they might stop smoking during pregnancy or might climb stairs more carefully to reduce possible risks to their unborn children.

Bibliography

1. Donald G. Pizzarello and Richard L. Witcofski, *Basic Radiation Biology*, Philadelphia: Lea and Febizer, 1967.

2. National Academy of Sciences – National Research Council, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*, Washington, D.C., November 1972.

3. National Council on Radiation Protection and Measurements, *Basic Radiation Protection Criteria*, NRCP Report No. 39, Washington, D.C., January 15, 1971.

4. United Nations, *Ionizing Radiation: Levels and Effects*, 2 vol., Reports of the United Nations Scientific Committee on the Effects of Atomic Radiation, Report No. A/8725, United Nations, New York, 1972.

5. U.S. Atomic Energy Commission, Division of Technical Information, Understanding the Atom Series:

   Atoms, Nature and Man

   The Genetic Effects of Radiation

   The Natural Radiation Environment

   Your Body and Radiation

Chapter IV

Steps to Reduce Radiation Exposure

Chapter 4 - Reduction of Dose

Dose From External Sources

Table VII gives the dose rate at a distance 30 centimeters from a 10 mCi source of some of the commonly used radioisotopes. Three factors which influence the dose received from external radioisotopes are:

1. Shielding
2. Distance
3. Time

Table VII

Shielding Facts

Isotope	*Unshielded Dose Rate 30 cm Away From 10 mCi Source mR/hr*	*Thickness of Lead to Reduce Dose by 10 (mm)*
Na-22	133	34
Na-24	200	48
P-32 (Bremstrahlung)	70	Lead not recommended
Cr-51	2	5
Co-57	10	0.5
Co-60	150	34
Zn-65	30	30
Se-75	22	3.5
Tc-99m	8	1.0
I-125	8	0.1
I-131	25	7
Cs-137	37	18

Shielding - Beta rays. Shielding of beta rays is usually accomplished by using aluminum, plastic or lead. A few millimeters of aluminum or plastic are effective as the range of even high-energy beta particles is short.

Shielding - Gamma rays. The shielding of gamma ray sources is accomplished by lead, steel, concrete or water. Lead is a good shielding material because it is dense and heavy. Table VII also gives the shielding thicknesses required to reduce the dose rate from some elected gamma emitters by a factor of 10.

Distance - A second method of reducing the dose rate is to get far away from the source so that fewer gamma rays will hit you. Just as a light is bright when you are up close, but gets dim as you move away, so the dose rate from a radioactive source decreases as you move away from it. Figure 7 shows how the dose rate decreases as the distance from the source increases. Moving twice as far away from a source reduces the dose rate by a factor of 4.

Time - Reducing the time spent near a radioisotope will reduce the total dose delivered to your body. Do not stand or sit next to unshielded sources except when actually working with them.

Unsealed Sources

Most laboratory procedures involve the use of unsealed sources. When working with unsealed sources we combine the techniques of shielding and distance with good housekeeping and extreme cleanliness. The aim of these efforts is to keep everything outside the body. The housekeeping steps which are recommended are:

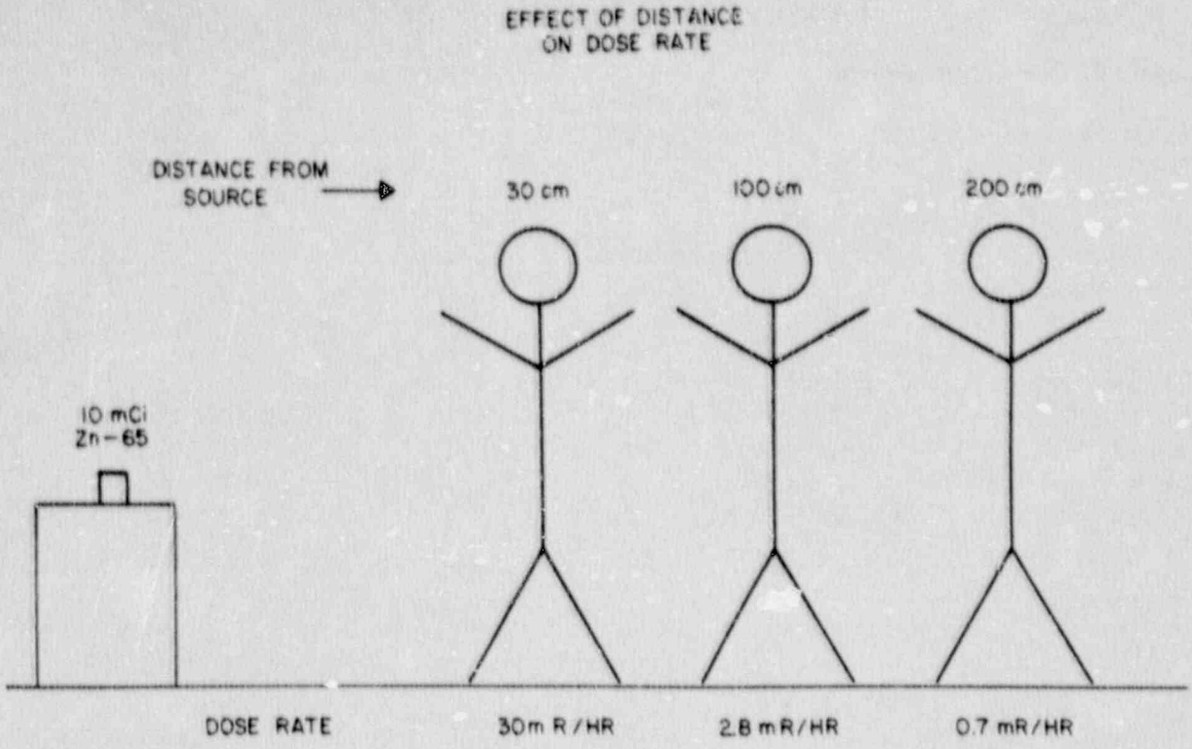

Figure 7

1. Always use an absorbent paper on a tray when working with radioactive liquids. The tray should be capable of containing the entire volume of liquid in case of a spill.
2. All operations should be performed in a fume hood if gas, vapor, dust or aerosols can be formed during the procedure.
3. Always wear plastic or rubber gloves and lab coats or aprons to prevent contamination of your hands and clothing when working with radioisotopes.
4. No mouth operations. Specifically this means no pipetting by mouth, no licking of labels, no eating, drinking or smoking in the laboratory.
5. Food or drink containers should not be stored in the same location as radioactive materials. This specifically means that refrigerators containing radioactive material are off limits for lunch sacks, milk cartons and other food or drink containers.

It is important to dispose of radioactive wastes properly to protect ourselves, our neighbors, and our environment. The four methods for getting rid of radioactive waste are:

1. Natural decay
2. Collection by the Health Physics staff
3. Disposal into the atmosphere
4. Disposal through the sanitary sewer

Natural Decay

For isotopes with short half-lives it is convenient to wait until their natural decay removes most of the radioactivity. After seven half-lives there will be less than 1 percent of the original activity remaining. This may be low enough so that there is essentially no activity left. When there is no detectable radiation, it can be disposed of as normal trash. No detectable activity means less than 0.05 milliroentgen per hour, or less than 100 cpm when monitored with a thin window GM tube in contact with the trash. For tritium wastes, no detectable activity means less than 0.005 microcurie in any one trash container.

Collection by Health Physics Staff

Radioactive waste given to the University Health Physicist for disposal by decay, incineration, or a disposal service are required to be in conformance with the following outline:

1. No animals or animal waste will be accepted by the Health Physicist unless you have made arrangements with him prior to the time of disposal. The persons collecting the radioactive waste have been instructed by the Health Physicist not to take any animals or animal waste under any circumstance.
2. Label all waste with the isotope present, the maximum amount, and the chemical form.
3. If you have hazardous chemical compounds with a radioactive label, indicate the chemical and its concentration in addition to the radionuclide.
4. Separate long and short half-life materials. Package all radionuclides separately.
5. Do not mix liquid waste with solid dry waste.
6. Put combustible and noncombustible waste in separate containers.
7. All liquids for the commercial disposal service must be neutral and nonreactive solutions.
8. Liquid waste volume is restricted to a maximum of five gallons per container, and a minimum of one gallon per container.
9. All one-gallon containers, glass or plastic, must be packed in boxes so bottles will not touch and break in transport on campus.
10. All chemicals or compounds, radioactive or nonradioactive, must be explicitly identified on each container and on the waste disposal form.
11. Disposal of liquid scintillation vials: A Health Physics memo discusses this in detail. Vials are taken either intact and full or empty with the liquid scintillation cocktail going to a waste solvent container.

Any variance from the above must be obtained from the Health Physicist on an individual basis. Only those packages in conformance with the above will be accepted by the Health Physicist; you will be requested to pick up your packages, left on the dock, that are not accepted.

Should any questions or problems arise because of the above procedures, please call the Health Physicist at 2-8769 or 2-4323.

Disposal into the Atmosphere

1. Pursuant to Section 20.106(b) and 20.302 of Title 10, Code of Federal Regulations, Part 20, the University of Wisconsin—Madison may dispose of, by incineration, (1) carbon-14 and hydrogen-3 in any combustible form and (2) by-product material, exclusive of carbon-14 and hydrogen-3, contained in animal carcasses and animal wastes provided:
   a. The total carbon-14 and hydrogen-3 activity incinerated per day does not exceed 50 millicuries;
   b. The total activity, exclusive of carbon-14 and hydrogen-3, per incineration of animal carcasses and animal wastes does not exceed 1 millicurie; and
   c. The concentration of released radioactive material does not exceed the limits specified in Section 20.106(b) of 10 CFR 20.
2. Other means of disposal into the atmosphere are any of the methods by which particulate or gaseous products are formed into a room or hood. If you know the quantity of a radionuclide and the volume of air in which it is diluted you can calculate the concentration of the radionuclide. The maximum concentrations which you can release are given in 10 CFR 20, Appendix B, Table II. The Regulations also require a record to be kept which shows the concentration of radionuclides released in effluents.

Disposal Through the Sanitary Sewer

Only very small amounts of radioactivity may be disposed of through the sewer (<2 mCi/approved faculty user/yr). Records of the date, type and amount of isotope disposed of via the sewer must be recorded. The approved procedure when cleaning containers of radioactive liquids is to empty liquid into a storage container, followed with one rinse into the storage container. One should prewash glassware before sending to a central cleaning facility as one would "normal dirty." Subsequent rinses can be discharged to the sewage system. When a storage container is full it can be disposed of through the Health Physics staff.

One exception to this cleaning procedure is the cleaning of scintillation vials. The amount of radioactivity contained in each vial is so small that the hazard is from the organic solvent rather than from the radioactivity. After emptying the scintillation vial into a storage container it can be washed directly as a nonradioactive vial. No rinses are necessary.

Under no circumstances are combustible solvents to be discharged into the sewage system. They are a serious fire hazard and a violation of most municipal and state codes.

Human Body Wastes

Human body wastes are specifically exempt from regulations on waste disposal. Radioactive human body wastes may be disposed of through the normal sanitary sewage system.

Normal Trash

It is extremely important that empty containers have all their radioactive tags and labels removed or defaced. There have been several false alarms caused by empty boxes which still had radiation labels attached. A can of black spray paint provides a quick and convenient way of covering over labels and tags.

Chapter 4

1. Three factors which influence the radiation exposure are: _____ , _____ and _____ .
2. _____ can be shielded by aluminum, plastic or lead.
3. _____ _____ can be shielded by lead, steel or concrete.
4. Moving twice as far away reduces the dose by a factor of _____ .
5. Mouth pipetting of radioactive liquids is always _____ .
6. Eating in a radioactive laboratory is _____ .
7. Protective gloves should be worn when working with _____ _____ .
8. Reactions which may produce vapors, dust or aerosols should be limited to a _____ .
9. _____ _____ wastes are exempt from the restrictions on radioactive waste disposal.
10. The four ways to dispose to radioactive wastes are: _____

Chapter V

Radiation Safety Procedures

Chapter 5 - Radiation Safety Procedures

Radiation Safety Surveys

Radiation surveys can detect areas of contamination, pinpoint areas that need improved laboratory procedures and locate areas that need additional shielding. Radiation safety surveys can be conducted with portable area survey meters and by wipe testing selected surfaces.

Survey Techniques

Areas suspected of contamination with gamma or high-energy beta emitters can be easily surveyed using a portable instrument. The meter is moved slowly around the area of interest and the meter readings at selected locations are recorded on a diagram of the room.

Wipe Tests

Wipe tests are the most effective way of routine monitoring for low-energy beta emitters such as tritium or carbon-14. The procedure used is to wipe an area about four inches square (100 cm^2) with a small piece of tissue. The tissue should be moistened with water or alcohol. Areas chosen to be wiped should be lab tables, hoods and other areas of possible contamination. The tissue is dropped into the scintillation vial and the proper amount of counting "cocktail" is added. The vial is then counted as a normal scintillation sample. Any sample over about two to three times normal background counting rate indicates an area of local contamination.

Incoming Package Inspection

The following is required for incoming packages and is quoted from 10 CFR 20.205:

20.205 Procedures for picking up, receiving, and opening packages.

(a) (1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b) (1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactivity contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcurie (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify the final delivering carrier and, by telephone and telegraph, the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D.

(c) (1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is

received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours.

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour, the licensee shall immediately notify, by telephone and telegraph, the final delivering carrier and the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D.

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

Always open and inspect packages immediately upon receipt. Radioactive solutions inadvertently stored upside down may gradually leak and cause contamination problems. Furthermore, vendors often will not accept claims for shipments not inspected within 15 days after delivery.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.000
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

Procedures Recommended for Handling Radionuclide Shipments

1. Monitor package for radiation field. (Plastic gloves should be worn while processing the received package.)
2. Wipe test package for removable contamination.
3. Note radiation units stated on package, verify and record in receipt log (HARD BETA AND GAMMA ONLY).
4. Place package in vented hood.
5. Open outer package and remove packing slip. Open inner package and verify that the contents agree in name and quantity with the packing slip.
6. Measure radiation field of unshielded container. If necessary, place container behind shielding to reduce field to allowable limits and proceed with remote handling devices (HARD BETA AND GAMMA ONLY).
7. Check for possible breakage of seals or containers, loss of liquid, or change in color of absorbing material.
8. Wipe test inner contents and document any pertinent findings on packing slip. Note: The liner, shield and isotope container may have surface contamination. They should be discarded in hot waste disposal containers if contamination is found.
9. Record type of activity, quantity present and location of delivery in receiving log.
10. Deliver processed package to proper laboratory. If delivery is delayed, notify recipient of its arrival and clearance.
11. If material has been packaged in dry ice, refrigerate or deliver immediately to ultimate user.
12. If contamination, leakage or shortages are observed, notify the vendor's Customer Service Department immediately by collect telephone call. Request instructions.

Emergency Actions

In the event of a spill or leakage of small or moderate amounts of radioactive material (less than 1 mCi) the steps to follow are:

1. Stop the spread of the radioactive material and limit the area of contamination.
2. Notify other people in the room or in the area that you have a problem.
3. Monitor personnel in the room to make sure that they are not contaminated and do not spread contamination around. If their clothes or bodies are contaminated, proceed with decontamination as soon as possible. A gentle washing with a mild soap is most effective when radioactive material has been spilled on the skin. Do not scrub or abrade the skin. Special care should be taken to remove all radioactive material from open cuts or wounds and to make sure they are washed thoroughly with clean water.

Cleanup Procedures

You should wear gloves and an apron or lab coat when you confine and pick up a spill. Paper towels or rags or tissues should be used to absorb a liquid.

When decontaminating an area it is important to have a separate container such as a plastic garbage bag available for holding all the contaminated gloves, tissues and rags which will be used during the decontamination. In most cases a careful cleaning of the surface followed by a second rinse either with plain water or with a mild soap or detergent is sufficient to provide adequate decontamination. Check with a survey meter or perform a wipe test to see that the radiation levels are less than three times the background level.

Fires

Fires are especially hazardous when associated with radioactive materials because the smoke and hot air currents can rapidly spread contamination throughout a wide area. In the event of fire:

1. Notify all persons in the room.
2. Call the fire department and the Health Physicist. Be sure to tell them that a potential radiation hazard exists.
3. Attempt to put out the fire only if you can do this with no risk to yourself.
4. Station a person near the entrance of the building to meet and direct the fire department to the fire and inform them of the possible hazard.

After the fire has been extinguished survey the whole area.

Chapter 5

1. To test survey a room for possible contamination by gamma emitters, a _____ _____ is moved slowly near areas of possible _____ .

2. _____ _____ which are counted in a liquid scintillation counter are the most effective method of testing for tritium contamination.

3. A damaged shipping container should always be checked for _____ .

4. In the event of a spill of less than 1 millicurie of radioisotope the first thing to do is to _____ the spread of radioactive material.

5. Persons working nearby should be _____ of a radioactive spill.

6. _____ _____ with a mild soap is the most effective way or removing radioisotope from the skin.

7. Cleanup of a spill is complete when the survey meter or wipe test shows that radiation levels are less than _____ times the background level.

Chapter VI

Current Regulations

Chapter 6 - Current Regulations

A summary of current regulations regarding the Maximum Permissible Dose (MPD) for radiation workers is presented in Table VIII. These limits are set by state and federal agencies. Anyone who wears a film badge, works with radioisotopes or sources of ionizing radiation is classified as a radiation worker. There is a separately stated limit for skin because beta particles can irradiate the skin to a high dose but deliver only a small dose to the tissue below the skin. The dose permitted to the hands and feet is larger because they contain no vital organs. These limits are set on the basis of experience and biological experiments. Persons exposed each year to the maximum permissible dose will not demonstrate any somatic effects during their lifetime.

The limits can be compared with natural background radiation levels. Background radiation comes from cosmic rays and radioactivity in the rocks and soil. Background levels vary from about 50 mR per year at sea level to about 150 mR at higher altitudes. In the Midwest the dose rate is approximately 125 mR per year. Table IX lists the maximum permissible continuous concentrations of some radioisotopes in the body. This value is called the Maximum Permissible Body Burden (MPBB). It is set so that a person with this concentration continuously in his body would not receive more than the maximum permissible dose.

Acceptable Risk

The goal of protection regulation is to reduce the risk to the radiation worker to a reasonable level. This means that no somatic effects from radiation will be expected during a radiation worker's lifetime, even if the worker receives the maximum permissible dose every year. Every individual must make his own decision as to what level of risk is acceptable. The hazards and effects of radiation have been extensively studied for over eighty years and are well understood when compared with other hazards such as air pollutants, etc.

Table VIII

Maximum Permissible Dose Limits

	Dose in mRem	
	Monthly	*Yearly*
Radiation Workers		
Whole Body	400	5000
Skin	2500	30,000
Hands	6000	75,000
General Population		
Whole Body		500

Table IX

Maximum Permissible Body Burdens (MPBB) for Selected Radioisotopes

Isotope	*MPBB (microcuries)*
Tritium	1000
Carbon-14	400
Sodium-22	10
Sodium-24	7
Phosphorus-32	6
Sulphur-35	400
Calcium-45	30
Chromium-51	800
Cobalt-57	200
Cobalt-60	10
Nickel-63	200
Zinc-65	60
Selenium-75	100
Technicium-99m	200
Iodine-125	1.0
Iodine-131	0.7
Cesium-137	30

It is wise to be aware of the hazards of radiation but you shouldn't be afraid of radiation. If you have further questions don't hesitate to ask your supervisor or the Health Physics staff.

Chapter 6

1. Natural background radiation levels are about _____ mR per year.
2. The maximum permissible dose for a radiation worker is _____ rem per year.
3. The maximum permissible dose to the general population is _____ mrem per year.
4. The _____ _____ _____ _____ is the maximum continuous concentration permitted in the body.

GLOSSARY

Activation	The process of making something radioactive.
Activity	A measure of the number of decays per second. Activity is measured in curies.
Alpha Particle	A helium nucleus having a mass of 4 and a charge of 2, i.e., two protons and two neutrons.
Alpha Emitter	A radioisotope which emits alpha particles.
Atom	The smallest part of an element. Made up of a nucleus surrounded by an electron cloud.
Background Radiation	Radiation from cosmic rays and natural radioisotopes in the earth.
Beta Particle	Fast-moving electron emitted during radioactive decay.
Beta Emitter	A radioisotope which emits beta particles.
Biological Half-Time	The half-time for elimination from the body of a substance in the nonradioactive form.
Cancer	An uncontrolled growth or tumor.
Cell	The basic building block of biology. Made up of a nucleus inside cytoplasm.
Chromosomes	Small structures in the cell nucleus which carry the genes and are important in passing on genetic information.
Contamination	Radioisotope in the wrong location. A radioisotope where it doesn't belong.
Curie	One curie corresponds to 3.7×10^{10} disintegrations per second.
Decay	The internal rearrangement of neutrons and protons within an atomic nucleus resulting in the emission of decay products.
Decay Products	Alpha particle, beta particle, or gamma ray emitted from a nucleus.
DNA	Abbreviation for deoxyribonucleic acid. A fundamental constituent of chromosomes. The DNA molecule is the carrier of the genetic information.
DNA Precursor	One of the biological building blocks which the cell uses to construct DNA.
Dose	The amount of energy deposited in a unit mass of the body. Dose is measured in rad (radiation absorbed dose).
Electron	Small atomic particle which usually carries negative charge. Weighs 2,000 times less than a proton.
Exposure	A measure of the ionization produced by X or gamma radiation. The unit of exposure is the roentgen.
External Radiation	Any radiation that comes from sources outside the body.
Film Badge	Small film packet used to measure radiation exposure to the body.

Gamma Ray	Electromagnetic radiation basically similar to light but invisible, and having higher energy and greater penetration.
Gamma Emitter	A radioisotope that emits gamma rays.
Geiger Mueller Counter	Gas-filled radiation detector tube operated at maximum sensitivity. So sensitive it can detect a single gamma ray.
Gene	That part of the chromosome which carries genetic information.
Genetics	Having to do with offspring or succeeding generations.
Genetic Effect	An effect on succeeding generations, chiefly mutations.
Half-life	The time required to reduce the original amount of radioactivity to half its original value.
Ion	A particle with either positive or negative electrical charge.
Ionization	Removal of an electron from an atom to produce an ion.
Ionization Chamber	A radiation detector which collects all ions produced in a gas chamber.
Internal Radiation	Radiation coming from sources within the body.
Isotope	Atoms having the same number of protons but different number of neutrons. Isotopes have the same chemical properties.
Labelled Compound	A chemical compound containing one or more radioactive atoms.
Leukemia	A malignant disease of the blood characterized by an excess number of white cells.
Maximum Permissible Dose (MPD)	Limits set on the dose to the body.
Microcurie (μCi)	3.7×10^4 disintegrations per second.
Millicurie (mCi)	3.7×10^7 disintegrations per second.
Milliroentgen (mR)	Unit of gamma ray exposure—10^{-3} roentgen.
Monitoring	The process of measuring and recording the amounts of radiation or radioactive contamination present in a specific location.
Mutation	A change in the genetic information carried by the genes.
Neutron	One of the building blocks of the atomic nucleus. Has zero charge.
Nucleus—Atomic	Dense central core of an atom.
Nucleus—Biological	Central part of a cell containing the chromosomes.
Photon	Electromagnetic radiation similar to light.
Proton	Positively charged particle inside the atomic nucleus. Has single positive charge.
Rad	Unit of absorbed dose—100 ergs/gram.

Rem	A unit of radiation dose obtained by multiplying the rad by a quality factor.
Radioactivity	Spontaneous disintegration of atomic nuclei resulting in emission of decay products.
Radioisotope	Isotope whose nucleus is unstable and undergoes radioactive decay.
Roentgen	Unit of X- and gamma ray exposure.
Scintillation	Light emitted after radiation absorption.
Scintillation Camera	Device containing a scintillation crystal used in nuclear medicine to locate radioisotopes inside the body.
Survey	To locate concentrations of radioactivity in a room or area.
Survey Meter	Portable radiation detector used to determine the amount and location of radioisotopes in an area.
Tracer	Compound containing a radioisotope used in chemical or biological experiments.
Tritium	Radioactive isotope of hydrogen containing 1 proton and 2 neutrons in the nucleus.
X ray	Electromagnetic radiation similar to light but having higher energy and greater penetration.

Answers to Questions

Chapter I

1. Radioactivity
2. Nucleus, electrons
3. Positive
4. Zero or neutral
5. Electrons
6. Isotope
7. Decay
8. Radioactive
9. Alpha particles; beta particles; gamma rays
10. Gamma rays
11. Half-life
12. Curies
13. Roentgens
14. Rads

Chapter II

1. Ionization
2. Ionization
3. GM tube
4. Survey meter
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7. Film badge
8. On the collar

Chapter III

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3. Inside
4. ½, excreted
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6. First
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8. Mutations
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Chapter IV

1. Shielding, distance, time
2. Beta particles
3. Gamma rays
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5. Forbidden, prohibited
6. Forbidden, prohibited
7. Unsealed sources
8. Hood
9. Human body
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    Atmosphere
    Collection by Health Physics

Chapter V

1. Survey meter, contamination
2. Wipe tests
3. Breakage or contamination
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5. Told or notified
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Chapter VI

1. 125
2. 5000 mrad
3. 500 mrad
4. Maximum Permissible Body Burden

University of Wisconsin-Madison

SAFETY IS OUR CONCERN...

SAFETY DEPARTMENT
317 N. Randall Avenue
MADISON, WISCONSIN 53715
608 262-8769 - 262-0667

18 June 1984

To: Authorized Users

From: Sue Engelhardt *Sue Engelhardt*
Health Physics Supervisor

Subject: Radiation Safety Regulations

Enclosed are the revised University Radiation Safety Regulations. Please remove everything from your yellow, three-ringed binder and insert this entire packet.

The regulations have not changed in content at this time. In the event of changes in the future, we will send them to you. Note that there is a page following the table of contents so that you can mark the date and the changes as they occur.

Although the regulations have not changed in content, we have changed the format; we have tried to shorten and clarify them. We hope that you find them easier to use!

Thank you.

University of Wisconsin·Madison

SAFETY IS OUR CONCERN...

SAFETY DEPARTMENT
317 N. Randall Avenue
MADISON, WISCONSIN 53715
608 262-8769 · 262-0667

TO: Authorized Users of Radioactive Materials

FROM: Sue Engelhardt *Sue Engelhardt*
Radiation Safety Officer

RE: RADIOACTIVE WASTE DISPOSAL CHANGES

Enclosed you will find Revision 2 to the University Radiation Safety Regulations. The changes are primarily for Section XIX, Disposal of Radioactive Material, but also include Table of Contents and Appendicies updates. Please read and insert these pages in your regulation binder and discard the old pages (call the Safety Department if you need additional copies). Remember to record the insertion of Revision 2 on the UPDATE RECEIVING RECORD located behind the Table of Contents.

The revised waste disposal regulations will be effective January 1, 1987, but a two month phase-in period will be in effect. Some additional information about the waste disposal changes follows. Please inform your lab personnel of the changes. If you have any other questions please call me or another health physicist.

WASTE IDENTIFICATION AND PACKAGING

We will provide, on a trial basis, boxes and plastic bags in three sizes for all radioactive solid wastes. Use the small box for your "hot" solids and liquids < 50 ml (e.g. stocks, concentrated products or wastes, etc.). The boxes are imprinted for waste identification. Complete the label on each waste box.

	L	W	H	(ft3)	USE
S -	6" X	6" X	4"	0.1	Concentrated solids and liquids <50 ml
M -	12" X	15" X	15"	1.5	Contaminated solids
L -	24" X	15" X	15"	3.0	Contaminated solids

Waste identification tags will also be provided for liquid wastes. Collect large volumes of liquid wastes in carboys or other nonbreakable containers, 500 ml - 4 liters. Waste identification tags must be completed and attached to all of these liquid waste containers (except for concentrated stocks < 50 ml put in the small waste box, just complete the box label). Two mCi or less of S-35 is now permitted in carboys, but keep S-35 seperate from H-3 and C-14.

Samples of the waste tags and new disposal forms are also enclosed. Request additional supplies from the Safety Dept. secretaries as needed. Please discard all your old, unused waste pickup forms.

DECAY

When significant, remember to correct your waste estimates for decay, or to report the date for your activity estimate on your disposal form - we will account for the decay on our end. Graphs are available to assist with P-32, S-35, Cr-51 and I-125 decay estimates (see Appendix I).

LIQUID SCINTILLATION COCKTAILS

Disposal procedures and costs for LSC wastes will depend on the type of product you use. Stores will stock 3 brands of sewer disposable liquid scintillation cocktails. The disposal charge for these cocktails will be $6/case as before. Alternatively, you may pour sewer disposable cocktails into aqueous waste containers or directly to the sewer (if within limits) at no charge.

Organic solvent cocktails (e.g. toluene) must be packaged in their original vials for pickup, in either full cases or in small boxes if you generate only a few. These LSC wastes will be repackaged for commercial disposal effective July 1, 1987. This will cost you about $30-$50 per case (500 vials). If you MUST use these cocktails, call me or another health physicist.

CHARGES FOR RADIOACTIVE WASTE DISPOSAL

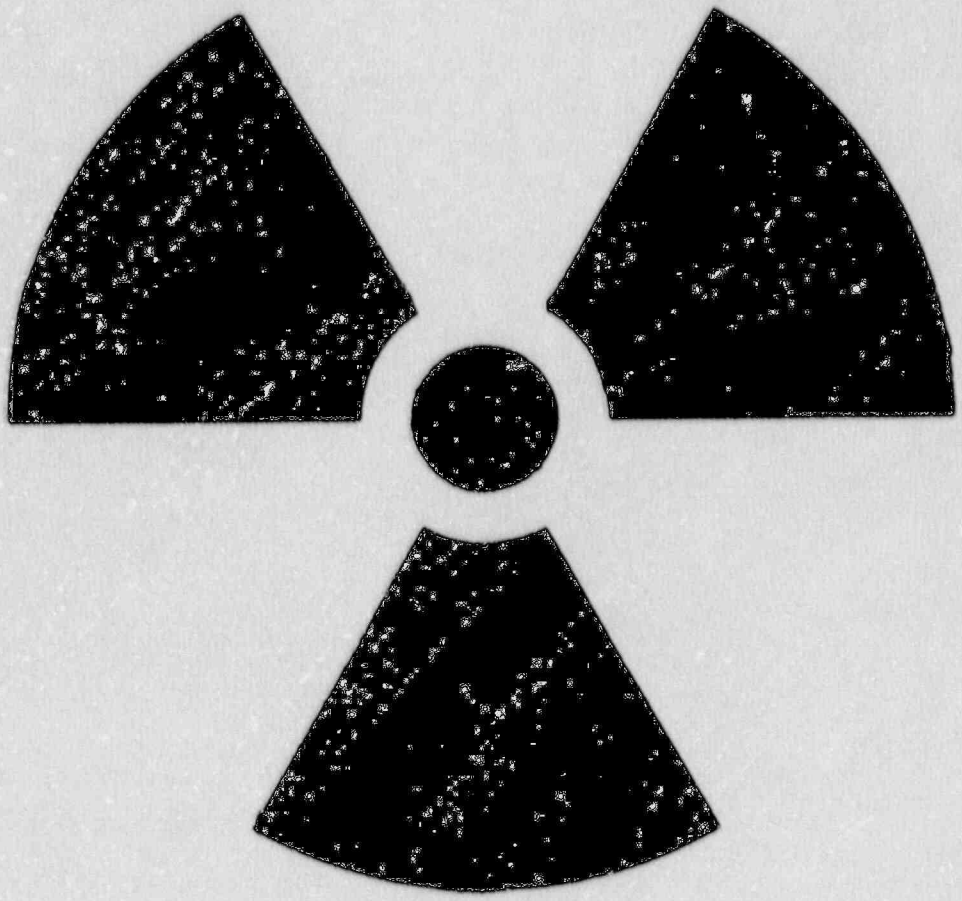
Some radioactive wastes incur additional disposal costs when shipped to a low-level radioactive waste disposal site (e.g. very large activites, mixed hazardous wastes, and some isotopes like Ra-226 and Am-241). We try to minimize these costs whenever possible. However, access to LLRW disposal sites in the near future and how current regulations will change is uncertain. The best assurance for continued waste acceptance is for you to promptly dispose of what you no longer want or need, and to call beforehand if you anticipate generating unordinary wastes.

UPDATE RECEIVING RECORD

Periodically, the Safety Department will distribute revisions to the University Radiation Safety Committee regulations. To help ensure that these revisions are received, keep a record of their insertion by filling in the chart below. The issue date will be recorded on the bottom of each revision. To check if your radiation safety regulations are current, please call Radiation Safety at 262-8769 or 262-0667.

REVISION NUMBER	DATE ISSUED	DATE INSERTED	REVISION NUMBER	DATE ISSUED	DATE INSERTED
1	3-7-86		11		
2	1-1-87		12		
3	3-15-88		13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

RADIATION SAFETY REGULATIONS



UNIVERSITY
of
WISCONSIN

UNIVERSITY RADIATION SAFETY REGULATIONS

TABLE OF CONTENTS

I. ADMINISTRATION OF THE UNIVERSITY OF WISCONSIN-MADISON RADIATION SAFETY PROGRAM

A. The University Radiation Safety Committee (URSC)

The URSC consists of faculty and staff appointed annually by the Chancellor (see Appendix A-1). Its duties are:

1. Advisory to university administration.
2. Set policy to insure compliance with local, state and federal regulations.
3. Prescribe enforcement action in radiation safety.
4. Evaluate authorizations and exceptions from radiation safety regulations.

B. The Medical Center Radiation Safety Committee (MCRSC)

The MCRSC is a subcommittee of the URSC appointed every two years by the Vice Chancellor of the Center for Health Sciences (see Appendix A-2). The MCRSC evaluates procedures for "human use" (internal or external administration to humans) of ionizing radiation.

See Section XII for more information about human use of radioactive materials.

C. The FDA Radioactive Drug Research Committee (RDRC)

The RDRC is a subcommittee of the MCRSC, appointed every two years by the Vice Chancellor of the Center for Health Sciences (see Appendix A-2). The committee reviews research proposals that involve administration of radioactive drugs to humans as specified by the Food and Drug Administration.

Further information on the jurisdiction of this committee can be found in 21CFR361.

D. The University Health Physics Staff

1. Provides staff assistance to the URSC in carrying out procedures and policies set forth by the committee and retains all related records.
2. Advises and assists faculty and staff.

E. The Authorized User

Authorized users are faculty members whose written applications for authorization for possession and use of radioactive materials have been approved by the URSC.

It is the authorized user's responsibility to assure compliance with regulations in his/her laboratories. THIS RESPONSIBILITY CANNOT BE DELEGATED.

F. The Radiation Worker

Individuals who use or work near radioactive materials or machines which produce radiation. These individuals must be trained by and work under the supervision of the authorized user.

II. RADIONUCLIDE AUTHORIZATIONS - NEW, RENEWALS, AMENDMENTS AND EXCEPTIONS

A. New Authorizations

Complete form 99 (Appendix B) and send it to the Safety Department. Complete ALL items.

1. Keep a copy of the application for your records.
2. Written notification will be sent as soon as the application has been approved or denied.
3. If approved your authorization is valid for up to 3 years.

> **NOTE: The University does not recognize any quantity of radioactive material as exempt from authorization except:**
> **a. Commercially available (manufactured) sealed standards and check sources with activities less than or equal to those specified in 10CFR30.71, Schedule B (Appendix V) and 10CFR31.**
> **b. Exempt devices as specified in 10CFR30 and 10CFR31 (copies are on file in the Safety Department; check with a health physicist). Tampering with these exempt devices is against the law!**

B. Renewal Authorizations

Written notification that your authorization is going to expire will be sent well in advance of the expiration date.

1. Complete a form 99 (Appendix B) and send it to the Safety Department; include any desired changes or exception requests.

> **NOTE: Incorporation of information by reference to previously submitted applications is not acceptable.**

2. Once your application is received in the Safety Department, it is considered to be under timely renewal.
3. Failure to submit an application by the deadline date will result in immediate revocation of your authorization for radioactive materials.
4. Written notification will be sent as soon as the

renewal application has been approved or denied.
5. Approval will be for up to, but not exceeding, 3 years.

C. Authorization Amendments

Requests for changes to your authorization are possible by submitting a form 99 or 99S indicating the desired change.

1. Submit the short form 99S (Appendix D) for additions or deletions of authorized radionuclide labs. Also, see Section IX, Final Surveys, for room deletions.
2. Keep a copy of the amendment for your files.
3. Written notification will be sent as soon as the amendment has been granted or denied.

D. Authorization Exceptions

If any University regulation is impractical for your radionuclide program, you may request an exception to that regulation. You may apply for more than one exception.

1. Send a written exception request to the Safety Department.
2. The exception is good only for the duration of your current authorization (i.e. it must be renewed with your authorization).
3. Exceptions may only be granted if they do not pose hazards or violate the terms and conditions of the University's NRC license or regulations.

E. Authorized User Absences in Excess of 30 Days

When an authorized user is going to be absent for more than 30 days, authorization must be transferred to another URSC approved user. Complete all items on form 99T, "Temporary Transfer of Authorization" (Appendix E), and submit it to Radiation Safety. The authorized user and substitute will be notified in writing of the URSC approval or denial of the temporary transfer.

F. Termination of Authorization

Authorization may be terminated at the request of the authorized user or the URSC. To terminate an authorization, the user must properly dispose of all radionuclides (as waste, by transfer to another user, etc.), perform final surveys of all radionuclide

facilities and contact Radiation Safety.

G. Further Information Pertaining to New Authorizations, Renewals, Amendments or Exceptions

1. You must comply with conditions and procedures described in your authorization - i.e. if you state that laboratory surveys will be done weekly this is what you must do.
2. If you have difficulty completing any items on an application form call Radiation Safety.

NOTE: Radiation Safety procedures for approval of authorization are:

1. **A health physicist reviews the application.**
2. **A health physicist will visit you if you are a new applicant and will answer any questions you may have. A visit may occur for a renewal, amendment or exception.**
3. **For new authorizations and exceptions, the applicant's University Radiation Safety Committee (URSC) representative and the chairman of the URSC will grant temporary approval. Final approval is granted by the entire URSC.**

See Section XIII, Part A for information on applications for human (medical) use.

III. SOURCES OF RADIONUCLIDES

All radioactive materials must be ordered through CORD (Central Ordering, Receiving and Distribution) located in the Safety Department. Ordering procedures for CORD and other legitimate methods of obtaining radionuclides follow.

A. CORD

CORD places all radionuclide orders with commercial vendors and UW Purchasing.

> **NOTE: Authorized users may not place orders directly with (nor receive radioactive materials directly from) commercial vendors. UW Purchasing will not process the order.**

The following explains how to order radionuclides.

1. CORD Hours: 7:45 AM to 11:45 AM &
   12:30 PM to 4:30 PM
   Phone: 262-6511
2. CORD Fee
   a. The CORD fee IS assessed for
      - each unique radionuclide/compound ordered
      - free samples and evaluation orders
   b. The CORD fee IS NOT assessed for
      - replacement shipments for damages, impurities, or CORD or vendor errors
      - radionuclide transfers between authorized users
3. Placing Orders
   a. Give this information to CORD when placing an order:
      - authorized user's name and department
      - room and building for delivery
      - compound name
      - preferred vendor and catalog number (CORD personnel will look up catalog information to help in order selection, prices . . .)
      - number of units needed and activity per unit
      - requisition number (see 4 below)
      - any instructions for special ordering, handling or storage while in transit
   b. Orders received by 11:45 AM will be placed with the vendor that afternoon. Orders received in the afternoon will be placed with vendors the following afternoon.
   c. CORD will notify the person who placed the order of any expected delays in shipments

d. Small quantities of certain materials (I-125, P-32 and Cr-51, formerly called aliquots) must be received by 11:45 AM Thursday to obtain the low bulk rate. The order will be delivered the following week on any afternoon you request.

4. Purchasing Radionuclide Orders

a. There are two types of internal requisitions for radionuclide purchases:
   - Blanket orders - money for several purchases for a designated period of time. Blanket orders expire when funds or time expire. Give the blanket order number for each order.
   - One time orders - a requisition processed for a specific order. It cannot be used again.

b. Initiate an INTERNAL requisition made out to:
   CORD / Safety Department
   317 N. Randall Ave.

It takes 3 to 14 days for the Purchasing Department to process a requisition (ask your departmental secretary for details). To order immediately, mail or hand deliver a copy of the requisition to the CORD office.

5. CORD Deliveries

All shipments received at CORD are opened, inventoried and stored for delivery. Any shipment received in CORD by 11:45 AM will be delivered that afternoon by the CORD technician.

NOTE: Individual vials should be handled with disposable gloves. They are not routinely checked for external contamination when received.

B. UW Reactor Lab

To receive materials from the reactor, users must be specifically authorized by the URSC on their Form 99. In addition, complete and file UWNR 134 "Request and Authorization for Services of the University of Wisconsin Reactor" (Appendix G).

C. UW Accelerator

Specific approval must be granted in the user's URSC authorization to receive radioactive materials from a UW accelerator. Details of registering receipt of such materials will be handled on a case-by-case basis by the URSC.

D. Transfer from Another Authorized User on the UW-Madison

Campus

1. Material in activities GREATER THAN levels specified in Appendix V (10CFR30.71, Schedule B).
   a. Before the transfer, the authorized user proposing the transfer must call CORD (2-6511) and inform them of the:
      - type of material
      - quantity (activity) of material
      - recipient and destination of the material
   b. If the transfer is between buildings, arrange for Safety to handle the transfer.
   c. If within the same building, the user may transfer the material (depending on the type and quantity of material, special arrangements may be desired). Safety must be notified in advance.

NOTE: When the transfer request is called in, CORD will fill out a "Radioactive Waste Pickup" form (Appendix I) and adjust the inventory of both the recipient and the transferrer. Copies of these inventory records will be given to the users.

2. Material in activities LESS THAN OR EQUAL TO levels specified in Appendix V (10CFR30.71, Schedule B).
   a. The person doing the transfer should call CORD (2-6511) and verify that:
      - the recipient is authorized for the type and quantity of material to be transferred.
      - transfer of this material will not exceed the recipient's possession limit
   b. The authorized person transferring the material must report the transfer on a "Radioactive Waste Pickup" form (Appendix I) within one week.

E. Transfer from Another NRC License or Off-Campus Source

This includes material from the VA Hospital, free samples, evaluation shipments, custom syntheses, etc.

1. All radioactive materials must be ordered AND shipped through CORD.
2. Instruct the shipper to send the material to:
   Safety Department / CORD
   317 N. Randall Ave.
   Madison, WI 53715

3. Call CORD and inform them of the impending shipment and any special handling necessary.
4. CORD will add the shipment to the authorized user's inventory and deliver the material when received.
5. If you should receive radioactive materials, contrary to your instructions, notify CORD immediately.

IV. FACILITIES FOR USE AND STORAGE OF RADIONUCLIDES

NOTE: The authorized user is responsible for providing adequate facilities for the proposed radionuclide use and storage.

A. Definition of a Radionuclide Laboratory

An enclosed space separated from adjacent areas by floor, ceiling and walls which extend from floor-to-ceiling with built-in closures for any openings in walls, floor or ceiling.

1. If unsealed sources of radioactive materials are used anywhere within the enclosure, the entire room is considered to be a radioactive materials area.
2. Exceptions to this may be granted by the URSC on a case-by-case basis.

B. Shielding

The authorized user must provide shielding so that exposures are kept as low as reasonably achievable (ALARA).

C. Fume Hoods

Fume hoods must have adequate air flow to ensure that restricted areas and hood effluents are below MPC (maximum permissible concentrations, see Appendix V, 10CFR20, Schedule B). See Section XII for information about using radioiodine in hoods.

D. Security

Radioactive materials, including waste, must be secured against unauthorized removal. See section VII for more information.

NOTE: Anyone who suspects that radioactive material has been lost or stolen must contact Radiation Safety immediately.

V. TRAINING AND INSTRUCTIONS REQUIRED FOR RADIATION WORKERS

It is the authorized user's responsibility to train their personnel in radiation safety techniques. Minimum training requirements are given below.

A. Radiation Safety for Laboratory Technicians (Handbook)

1. All persons who will work in a radionuclide facility (even if they do not handle radioactive materials) must read this manual, and take and pass the exam (Appendix K) before they begin work.
2. Completed exams are to be submitted to the Safety Department. Exams are graded and returned to the authorized users.
3. Alternative training may be acceptable; contact Radiation Safety.

> **NOTE: Students participating in classroom laboratory exercises where radionuclides in total quantities less than those listed in Appendix V (10CFR30.71, Schedule B) do not need to take the exam.**

4. Individuals who leave employment with one authorized user and begin employment with another need not retake the exam if the exam was successfully completed within one year of transfer of employment.

B. Changes in Personnel

Authorized users must notify the health physics staff when a person discontinues work in their radionuclide facility.

C. Additional Instructions Required for All Persons Working With or Exposed To Radionuclides

Authorized users are responsible for providing their personnel with the instructions specified in 10CFR19.12, "Instructions to Workers":

1. Persons working in or frequenting any portion of a restricted area will be informed as to the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area.
2. Persons will be instructed as to the hazards associated with working with radioactive materials or radiation.
3. Persons will be instructed as to precautions and

procedures to minimize radiation exposure.

NRC Form 3 (Appendix L) provides "Notice to Employees" to be posted where every radiation worker will see it.

VI. PERSONNEL MONITORING

Authorized users are responsible for insuring that persons working for them have and wear dosimeters when required by federal (NRC) or University regulations.

A. NRC Requirements

The NRC regulations require that personnel monitoring equipment be used by:

1. Each person who enters a restricted area under circumstances where he could receive or is likely to receive a dose greater than 25% of the quarterly dose limits (see table below).
2. Each person who is under 18 years of age who enters a restricted area under circumstances where he could receive 5% of the applicable allowable dose for a calendar quarter (see table below).
3. Each person who enters a high radiation area ($\geq$ 100mrem/hr).

Occupational dose limits per calendar quarter (mrem)		Levels requiring personnel monitoring (mrem)	
		25%	5%
Whole body, head and trunk, active blood forming organs, lens of eyes, or gonads	1,250	312	62
Hands and forearms, feet and ankle	18,750	4,680	937
Skin of whole body	7,500	1,875	375

B. University Requirements

Dosimeters are required for all workers who use 1 mCi or more of radioactive material which decays with product energies as specified below:

DECAY PRODUCT	ENERGY	BADGE TYPE
beta	$\geq$ 500 keV (maximum energy)	body extremity*
gamma	$\geq$ 20 keV	body extremity**

* Unless shielding will prevent extremity exposure
** If operation is such that extremity exposures could not be ascertained from the body badge (e.g. body is shielded)

C. Obtaining Dosimeters

1. Contact the individual responsible for administering badges to your group (or Radiation Safety).
2. Complete a Form 135 (Appendix M) and submit it to Radiation Safety.
3. If you lose a badge call Radiation Safety and submit a missing badge report (Appendix N).

> **NOTE: Your department will be billed for badges that are not returned within 30 days of the end of a monitoring period.**

D. Dosimetry Records and Overexposures

Exposure histories can be obtained from Radiation Safety. It is the authorized user's responsibility to:

1. Inform personnel where dosimetry records are posted and filed.
2. Provide necessary information to Radiation Safety to evaluate any recorded overexposures.

> **NOTE: Radiation Safety will review dosimetry records for overexposures and conduct investigations on those exceeding 50% of the maximum permissible dose.**

E. Further Information Relating to Personnel Dosimetry

Some important "musts" for dosimeters:

1. Store dosimeters where they will not inadvertently be exposed to ionizing radiation, excessive heat or moisture.
2. Wear only the dosimeter assigned to you.
3. Body badges - wear on the trunk of your body at the point where it is most likely to receive maximum exposure.
4. Ring badges - if you are right handed, wear the ring on your right hand.
5. Lead aprons - if wearing a lead apron, wear the badge on your collar (outside of the apron).
6. Turn in the dosimeter to your badge group leader by the 25th of the month that the badging period ends. Make sure you have been issued a new dosimeter before turning in the old one.

7. If you leave the University, turn your badges in to your badge group leader.

If you have questions contact Radiation Safety. DO NOT CONTACT THE VENDOR.

NOTE: If you suspect that you or your dosimeter may have been overexposed or contaminated call a health physicist immediately.

VII. SECURITY OF RADIOACTIVE MATERIAL

Authorized users are responsible for the security of all radioactive materials in their possession including radioactive waste in storage. NRC regulations allow for the use and storage of radioactive materials in two types of areas:

A. Restricted Area is any area to which access **IS** controlled by the licensee for purposes of protection of individuals from exposures to radiation and radioactive materials (e.g. radionuclide labs).

1. Areas where radioactive materials are routinely used or stored are usually designated as restricted areas. Such areas must be conspicously posted at each entryway with two signs: one, the conventional radiation caution symbol and the words **"CAUTION: RADIOACTIVE MATERIAL"**, and the other **"RESTRICTED AREA: AUTHORIZED PERSONNEL ONLY"**. Such posting shall constitute control over the restricted area.

2. Occupational dose limits apply to individuals in restricted areas (5000 mRem per year).

B. Unrestricted Area is any area to which access **IS NOT** controlled by the licensee for the purposes of protection of individuals from exposure to radiation and radioactive materials.

1. (a) Licensed materials stored in unrestricted areas shall be secure from unauthorized removal from the place of storage. Such areas include locked and labelled ("CAUTION: RADIOACTIVE MATERIAL") refrigerators and cabinets in hallways and on loading docks.

(b) Licensed materials in unrestricted areas and not in locked storage shall be tended under the constant surveillance and immediate control of an authorized user.

2. Radiation exposure levels below 0.6 mRem per hour are permitted in unrestricted areas.

Restricted areas containing very large quantities of radioactive materials may require additional security measures beyond those listed above.

VIII. FOOD, BEVERAGES, SMOKING, ETC. IN RADIONUCLIDE FACILITIES

The following activities are prohibited in laboratories where unsealed sources of radioactive materials are present:

1. Consumption, preparation and/or storage of food, beverages or medications.
2. Application of topical medication or cosmetics.
3. Smoking and tobacco chewing.
4. Mouth pipetting.

IX. LABORATORY SURVEYS AND CONTAMINATION

Authorized users are responsible for insuring that adequate surveys for contamination are conducted in their radionuclide facilities where UNSEALED SOURCES of radioactive materials are used or stored.

A. Survey Frequency

NOTE: The authorized user is required to conduct surveys as specified in his/her authorization to possess and use radioactive materials.

1. The minimum survey frequency is determined by the amount of radioactivity used at any one time. Opening a bottle, vial, etc. or having waste present constitutes using radioactive material.

FREQUENCY		ACTIVITY USED
IMMEDIATELY AFTER THE USE of	≥	5 mCi of radioiodine
or	≥	50 mCi of radioiodine (send copy to Safety)
Monthly	≥	200 uCi at any one time
Semiannually	<	200 uCi or if radioactive materials are in storage only

2. Materials in storage -
A survey must be conducted after the last use before the material may be considered to be in storage.

B. Adequate Surveys

This part is to provide general guidelines for surveys of facilities where unsealed sources of radioactivity are used or stored; it will not cover all uses and situations.

1. Low energy beta emitters - wet wipe tests for removable contamination are required.
2. High energy beta and/or gamma emitters - a check of exposure levels is required in addition to wipe tests for removable contamination.
3. Surveys for removable contamination - wipe tests must be conducted in all areas where radioactivity is handled or stored in an unsealed form and must be taken with moist smears, swabs, etc. covering an area of approximately 100 sq cm. CAUTION: Do not cross-contaminate wipe tests. Results of the survey

must include:
a. Location and date
b. Diagram of the area surveyed
c. Identification of person doing the survey
d. Type of counter used
e. Background count for wipe tests
f. Measured counts for wipe tests keyed to locations on the survey diagram

> **NOTE: Areas with removable activity (counts) in excess of 10 times background are considered contaminated and must be cleaned and then resurveyed.**

g. If contamination is found, a record of the resurvey after decontamination must be kept.

4. Surveys for exposure levels - A calibrated survey meter, sufficiently sensitive to detect 0.1 mR/hr (e.g. GM), must be used. Results of the survey must include:
   a. Location and date
   b. Diagram of the area surveyed
   c. Identification of person doing the survey
   d. Type of survey meter used
   e. Background exposure rate measured outside the radionuclide facility and away from potential radiation fields
   f. Measured exposure rates keyed to locations on survey diagram
   g. In the event of excessive exposure rates, documentation of corrective action taken and record of exposure rates following corrective action

> **NOTE: Results of wipe tests and exposure levels may be recorded on the same survey map. A sample map is included, see Appendix O.**

C. Final Surveys

If an authorized user wants to remove a room from his/her authorization or designate an area that contained unsealed sources of radioactive materials as an unrestricted area (i.e. not restricted by these regulations), a thorough final survey must be done. (See Adequate Surveys, part B, above.)

NOTE: A copy of the final survey must accompany a completed form 99S (Appendix D) and be approved by Radiation Safety before the room will be removed from the authorized user's list of areas for storage and use of radioactive materials.

D. Posting and Record-Keeping Requirements

1. A copy of the most recent survey must be posted in each laboratory.
2. Previous surveys must be available for perusal by the Radiation Safety staff and employees of federal and state agencies.
3. Survey records must be retained for a minimum of 2 years.

X. SEALED SOURCES - LEAK TESTS

A sealed source is any radioactive material that is permanently encapsulated to prevent leakage or escape of radioactive material. Contact Radiation Safety if you wish to fabricate a sealed source.

NOTE: Radiation Safety is required to perform leak tests and keep records for all sealed sources.

If you receive a sealed source or a piece of equipment containing a sealed source (e.g. gas chromatograph EC foils or vacuum gauges) call Radiation Safety so we can add it to the leak test schedule if required.

XI. INSTRUMENT REQUIREMENTS FOR SURVEYS AND MONITORING

The authorized user must have available the instruments listed in his/her authorization.

A. Portable Survey Meters (e.g. GM)

1. Availability
   Survey meters must be operating and in the vicinity wherever unsealed sources of energetic beta emitters or gamma emitters are being handled.
2. Calibration frequency
   Meters must be calibrated at the frequency specified in your radionuclide authorization but at least once per year. The Safety Department will calibrate a limited number of meters and will notify you in advance of the calibration due date. Bring the survey meter to the Safety Department (label with authorized user name and phone number).

> **NOTE: Notify Radiation Safety when you purchase a survey meter so it can be added to the calibration schedule. Some types of meters must be sent to an alternate calibration service; the user is responsible for calibration fees and other charges.**

3. When you bring a meter to the Safety Department plan to wait a few minutes while your meter is logged in.

B. Liquid Scintillation Counters or Gas Flow Counters

Individuals using low energy beta emitters must have access to one of these types of counters.

XII. CONTAMINATION AND RADIATION LEVELS

A. Contamination

> **NOTE: Contamination is present when levels of removable radioactivity in excess of 10 times background are detected.**

When contamination is detected, the following procedure should be followed:

1. Don protective clothing, i.e. rubber gloves, lab coat, etc.
2. Clean area thoroughly.
3. Remonitor the area.
4. Document surveys and resurveys (see Section IX, Adequate Surveys).

If the contamination cannot be cleaned, clearly label the area to prevent spread of contamination and call Radiation Safety for assistance.

> **NOTE: For spills and contamination problems, contact Radiation Safety immediately.**

B. Survey Requirements Prior to Operations by Non-Radiation Workers

Non-radiation workers include carpenters, electricians, steamfitters, etc.

1. Removable Contamination
   a. Survey the area or equipment to be worked in or on by the non-radiation worker and decontaminate if necessary.
   b. Clearly mark the area or equipment as being free of contamination.
   c. Notify Radiation Safety that work is being done by non-radiation workers.
2. Radiation Levels
   Non-radiation workers may not work in any area where exposures could exceed:
   a. 2 mrem in any one hour or
   b. 100 mrem in seven consecutive days (to an individual continuously present in the area).

The authorized user must retain documentation of these surveys and provide a copy to the worker upon request.

XIII. RADIONUCLIDE USES WITH SPECIAL REQUIREMENTS

The following five areas have special requirements:

A. Human use
B. Radioiodine use
C. Tritium use
D. Animal use
E. Airborne radioactivity

A. Human Use

This is the internal or external administration of radiation to humans for diagnostic, therapeutic or investigative purposes. Information on acceptable training and experience for medical uses of byproduct material may be found in Appendix F-1. The following procedures are required for obtaining authorization.

1. Submit a completed form 99, "Application for Possession and Use of Radioactive Materials" (Appendix B), to Radiation Safety.
2. Submit a completed form 98, "Application for Human Use of Radionuclides" (Appendix F-2), to Radiation Safety.
3. The application will be evaluated by the Medical Center Radiation Safety Committee which meets at least semiannually.

> **NOTE: It is committee policy to deny a "human use" application if two members oppose the proposal.**

4. The authorized user will receive written notification when his/her authorization has been granted or denied.

B. Radioiodine Use

> **NOTE: Contact Radiation Safety immediately of suspected inhalation, spills, excessive releases or excessive exposure to personnel.**

There are special monitoring requirements for users of radioactive iodine.

1. Use of a Fume Hood or Approved Facility
   Procedures involving 100 uCi or more of radioiodine must be performed in a fume hood or other facility that has been approved by Radiation Safety.

> **NOTE: Hoods should be left running continuously. Notify Radiation Safety if the hood has to be shut down.**

2. Evaluation of Radioiodine Concentrations in Air

   Breathing Zone Air monitoring is required during procedures involving 1 mCi or more of volatile radioiodine or 10 mCi or more of non-volatile radioiodine. The steps in this monitoring are as follows:
   a. One activated charcoal filter will be delivered with your radioiodine order from CORD.
   b. Insert the filter in the line attached to the vacuum source.
   c. Turn on the vacuum source and note the time. The vacuum supply must run continuously while the iodine procedure is being performed.
   d. Maximize sample flow rate.
   e. Record the flow rate as indicated by the flow meter in the breathing zone monitoring line.
   f. After the radioiodine procedure is complete, turn off the vacuum pump, put the filter in its plastic bag and fill in the required information on the label.
   g. You must bring the filter to CORD when you come in for a thyroid count.

3. Thyroid Bioassays

> **NOTE: Due to the bioassay requirement being "within 7 days of receipt", users are advised NOT to order their radioiodine more than a couple of days in advance of its intended use.**

BIOASSAY TYPE	TIME	ACTIVITY LEVELS	
		Volatile	Non-volatile
Background	Within 6 months of use	100 uCi	1 mCi
Post-use	Within 7 days of receipt*	100 uCi	1 mCi

*An extension for I-125 may be granted upon request,

but not to exceed 14 days (extensions for I-131 are not possible)

a. Scheduling thyroid counts
   - Call CORD and schedule a thyroid count within 7 days of receipt of radioiodine.
   - Bring your breathing zone monitor to the CORD office (Safety Department) at your scheduled time.
   - There is a $15 fee for the count.

b. If radioiodine is detected
   - The individual will be notified in writing of the uptake.
   - If the uptake is greater than 50% of 40 MPC hours, two weekly thyroid counts will be scheduled and then every 4 weeks until background levels are indicated (at no additional cost).
   - The authorized user will be required to submit a written proposal of action to be taken to prevent recurrence if an uptake is greater than 50% of 40 MPC hours.

4. Effluent Monitoring

The Radiation Safety staff will monitor the hood effluent at the point of exhaust and retain all records.

a. Notify Radiation Safety if the fan breaks down or is to be turned off for some reason. Hoods may not be turned off without written permission from Radiation Safety.
b. The authorized user may see his/her effluent monitoring results at any time by calling Radiation Safety.

NOTE: An annual summary of the effluent monitoring for each radioiodine hood will be provided to the authorized user upon request.

5. Special Surveys

Meter and wipe surveys must be performed and documented immediately after each use of $\geq$ 5 mCi of radioiodine. This survey must be posted and saved for two years like all other room surveys. See Part IX of these regulations.

After each use of $\geq$ 50 mCi of radioidine a copy of this special survey must be submitted to the health

physics staff for review.

C. Tritium Use

Procedures which have the possibility of producing airborne tritium must be conducted in a fume hood or other approved facility. Some uses may require the authorized user to provide an adequate system of breathing zone and/or effluent monitoring to assure regulatory levels are not exceeded.

1. Urine bioassays are required from persons working with 10 mCi or more of unsealed tritium.

BIOASSAY TYPE	TIME
Background Count	Within 6 months prior to use
Post-use Count	Within 1 week during and after procedure*

* If any activity is detected, weekly post-use bioassays are required until background counts are reached.

NOTE: "Working with" includes withdrawing any amount of the tritium from a stock solution of 10 mCi or more, even though the quantity used in the experiment may be less than 10 mCi.

2. Bring the sample to the Safety Department in the labelled vial provided. DO NOT SEND SAMPLES THROUGH INTERCAMPUS MAIL.
3. A copy of the results will be sent to each person submitting a sample.

D. Animal Use

To use radioactive materials in animals, the authorized user must submit a completed form 99A (Appendix C) to the Safety Department.

1. The application must be approved by the URSC.
2. The authorized user will receive written notification of approval or denial.
3. The authorized user is responsible for assuring:
   a. training of animal care personnel.
   b. that radioactive animals are not moved to unauthorized facilities.
   c. proper labelling of animal rooms and cages.

NOTE: Each cage must be labelled as follows:
- **"Radioactive materials" label**
- **Radionuclide and amount administered**
- **Date administered**
- **Name and phone # of authorized user**

d. Proper disposal of animals, bedding, food and waste (see Section XIX).

E. Airborne Radioactivity

Authorized users having procedures and/or materials with the potential for producing airborne radioactivity (gases, aerosols or dusts) must perform their operations in a hood or other approved facility.

XIV. RECORD KEEPING AND INVENTORY

The authorized user is required to maintain up-to-date records of radionuclide use, decay and disposal.

A. Authorized User Responsibility

1. Retain a log book where receipt, use and disposal of radioactive materials is recorded AS IT OCCURS. Appendix Q is provided with each order and should be used for record keeping purposes.
2. Be able to ascertain total activity for each radionuclide at any time. If short lived radionuclides are used, decay must be recorded monthly.
3. Log book must be available for inspection by Radiation Safety at any time.
4. Keep copies of all CORD, disposal and transfer forms on file for Radiation Safety perusal.

NOTE: Discrepancies in inventory records must be resolved immediately.

B. Radiation Safety Responsibility

1. Maintain a running inventory for each radionuclide an authorized user possesses based on records from CORD, user disposal forms and transfer reports.
2. Prevent authorized users from exceeding their possession limits or receiving unauthorized radioactive materials.
3. Assure the NRC license limit and building limit for any one radionuclide is not exceeded.
4. Check user inventory records during routine Radiation Safety inspections (this may involve a physical inventory).

XV. TRANSPORTATION AND SHIPMENT OF RADIOACTIVE MATERIALS

A. On Campus

1. Activities less than or equal to those listed in Appendix V may be transferred between buildings by the authorized user.
2. Activities greater than those listed in Appendix V must be transferred BETWEEN buildings (but not within the same building) by Radiation Safety. Call CORD a day in advance to schedule transfers.

NOTE: The authorized user providing the material must call CORD (262-6511) BEFORE each transfer to another authorized user.

See Section III, Part D for more information.

B. Off Campus

Transfers to off-campus sites, including the VA Hospital, must first be approved by a health physicist regardless of the quantity. Authorized users, or their personnel, may ship limited quantities of radioactive materials off campus, directly from their labs, PROVIDED HEALTH PHYSICIST APPROVAL IS SECURED PRIOR TO EACH SHIPMENT. See Appendix R for more information about radionuclide shipments.

NOTE: Transfers between users and shipments off campus are methods of disposal and will result in removal of the radioactivity from your inventory. Radiation Safety will complete and send you a waste disposal form for each approved transaction.

XVI. POSTING AND LABELLING REQUIREMENTS

These requirements are based on federal regulations except that no distinction is made between ionizing radiation emitted by radioactive materials and machine produced radiation.

A. Signs

Appropriate "caution" signs will be provided whenever a facility is approved as a restricted area (e.g. when authorization is granted or amended).

B. Other Posting Requirements

1. NRC Form 3 - "Notice to Employees", Appendix L
2. "Notice to Workers" informing workers that the NRC license and related documents (Parts 19 and 20 of Title 10, Code of Federal Regulations - Appendicies T and U) and operating procedures are available for examination at the Safety Department. This notice is a card usually attached to NRC Form 3.
3. A list of names and phone numbers of persons who can provide assistance or answer questions regarding radiation safety (see Appendix H).
4. "No smoking no eating no drinking" signs.

C. Container Labelling

Each container of radioactive material (including waste) must be labelled with a durable and clearly visible label identifying the radioactive material contents. The label must contain the radiation symbol, the words "Caution Radioactive Materials", the activity and identity of the radionuclide and the date for which the activity was determined.

"Radioactive" yellow tape may be purchased from the Safety Department.

XVII. RECOMMENDATIONS FOR PERSONS USING UNSEALED SOURCES OF RADIOACTIVE MATERIALS

A. Precautions to Take when Working with Unsealed Sources of Radioactive Materials

1. Wear lab coats, disposable gloves and safety glasses. When leaving the lab, these items should be left in the lab.
2. Cover work area with plastic backed absorbent material and/or a nonporous tray.
3. Assume all radioactive material containers are contaminated.
4. Do a "dry run" without radioactive materials to learn new procedures.
5. Radiation workers should be thoroughly familiar with the properties of the radionuclides they are using. If you are uncertain about the safety of a procedure call Radiation Safety.

> **NOTE: Pamphlets with useful technical information for some radionuclides are available from the Safety Department.**

6. Employ the three basic rules whenever working with radioactive materials - time, distance and shielding.
7. Monitor gloves, clothing and work area after each use of a high energy beta or a gamma emitter.

B. Some Important DO "NOTS"

1. DO NOT work with radioactive materials if you have an open wound.
2. NO mouth pipetting.
3. NO personal belongings in active areas of the lab.
4. NO food, beverages or smoking.

XVIII. EMERGENCY PROCEDURES

A. Phone Numbers

Police and Security (P & S): 262-2957
P & S will be able to contact health physicists during or after business hours.

Radiation Safety: 262-8769 or 262-0667
Refer to Appendix H for additional emergency numbers.

B. General Procedures

1. Do not risk external or internal exposure to save equipment or an experiment. Modification of this point should be only at the direction of a person qualified to estimate the hazards involved.
2. In all cases of serious physical injury, medical attention and hospitalization take precedence over other concerns.
3. In an absolute life-or-death situation or to avoid a more serious (i.e. potentially life-threatening) hazard, it is permissible to allow a rescuer to receive an external radiation exposure of up to 25 rem.
4. Immediately following a spill or dispersion of radioactive materials, take appropriate precautions to confine the material; i.e. control access to the area, turn off the ventilation system, prevent the spread of liquids and limit the movement of involved and possibly contaminated individuals.
5. Contact Radiation Safety.

C. Detailed Procedures

1. Minor Spills - NO radiation hazard to personnel
   a. Notify all other persons in room and area at once.
   b. Monitor all individuals involved in incident for contamination.
   c. If contamination is found, have individuals change clothing and wash as necessary, then remonitor.
   d. Limit access to the area of the spill to those persons needed for clean-up.
   e. Confine the spill (wear protective gloves).
      i. Liquid spill - drop absorbent paper on the spill
      ii. Dry spill - dampen the spill but do not spread. Dampen with water, or oil if a reaction (generating air contamination)

would occur with water.

iii. Notify the health physicist if you need assistance.

iv. Decontaminate. Make a plan first!

v. Permit no entrance into the area until it is checked by the health physicist or decontamination is achieved.

vi. If quantities of radioactivity in excess of those specified in Appendix V are involved, prepare a history of the spill and subsequent remedial or protection measures taken. Send the report to the health physicist. The authorized user and each individual involved must sign the report.

2. Major spills - involving radiation hazards to personnel

a. Have all persons not involved in spill leave area at once. Restrict movement of displaced persons as necessary to prevent possible spread of contamination.

b. If spill is liquid and the container is intact, return it to the upright position using gloves or a lever.

c. If spill is on skin, flush thoroughly.

d. If spill is on clothing, remove contaminated clothing.

e. Switch off all fans and ventilators which might transport vapors or dust to other rooms.

f. Vacate and seal the room. Keep all personnel out.

g. Immediately notify radiation safety at 262-8769/0667 or call P & S at 262-2957.

h. Take immediate steps to decontaminate affected personnel.

i. After the arrival of the health physicist, decontaminate the area.

j. Monitor persons involved in spill and cleanup.

k. Suspend work in area until the health physicist completes monitoring and gives approval.

l. Prepare history of the spill and cleanup and forward to Radiation Safety within 72 hours. The authorized user and each individual involved must sign the report.

3. Accidents Involving Radioactive Dusts, Fumes and Gases

a. Have all persons leave area at once. Restrict movement of displaced persons as necessary to prevent possible spread of contamination.

b. If possible, close air vents and seal off area.
c. Notify Radiation Safety (262-8769 or 262-0667) or Protection and Security (262-2957) or use the phone list in Appendix H.
d. Close and lock doors and/or post guards to prevent entry into area.
e. Monitor all persons suspected of contamination. Proceed with decontamination of personnel.
f. Report all known or suspected inhalations of radioactive material to health physics personnel.

With the aid of health physics personnel:
g. Evaluate hazard and necessary safety devices for reentry.
h. Determine cause of contamination and rectify the condition.
i. Decontaminate.
j. Perform air survey. Do not allow work in area to be resumed until approval of the health physicist is obtained.
k. Prepare a history of accident and subsequent action and submit to Radiation Safety.

4. Injuries to Personnel Involving a Radiation Hazard
   a. If contamination is a possibility, wash minor wounds immediately.
   b. Notify University Hospital Emergency Service to obtain medical assistance.
   c. Report incident to Radiation Safety as soon as possible.
   d. Prepare a history of the incident and forward to Radiation Safety.

5. Fire or Other Major Emergency
   a. Notify all other persons in room and building at once.
   b. Notify Police and Security (262-2957). Inform them if a radiation hazard exists with the fire. They will notify the Fire Department and Radiation Safety.
   c. Attempt to put out the fire if radiation hazard is not immediately present.
   d. Following the emergency, monitor the area and decontaminate if necessary.
   e. Monitor all personnel involved in the emergency.
   f. Do not resume work in the area until approval of the health physicist is obtained.
   g. If a radiation hazard was involved, prepare a

history of the incident and forward to Radiation Safety.

6. Known or Suspected Overexposure of Personnel
   a. Eliminate cause of suspected overexposure or keep people away from area where a high radiation level exists.
   b. Send overexposed personnel to University Hospital Emergency Service (hospital telephone operators have a Radiation Emergency Notification list).
   c. Notify the health physicist or University Radiation Safety Committee Chairman or, if these people are not available, any member of the URSC (see Appendix A-1).
   d. collect dosimeters, TLD badges, etc., for immediate reading and estimation of the dose. If not available, get sufficient information to calculate exposure.
   e. With the assistance of the health physicist or URSC Chairman, determine whether reporting to the NRC is required. If a report is necessary, you will be given assistance in making it.
   f. A written report of all overexposures shall be sent to the health physicist describing the cause of such overexposure, whether or not reporting to the NRC is required.

D. Written Histories and Reports

1. The following is a guide to preparing histories or reports as required above:
   a. What happened (i.e. type of accident, cause, how discovered, etc.).
   b. When (time and date).
   c. Where (building, floor, area, etc.).
   d. Who was involved (names and responsible staff members).
   e. Who was exposed to radiation or physically injured (name and extent of exposure or injury).
   f. Damage to facilities (University and non-University).
   g. Is radioactive contamination a problem?
   h. Corrective action taken.
2. Reports are to be sent to Radiation Safety. These reports will be reviewed by the University and/or Medical Center Radiation Safety Committee.

XIX. DISPOSAL OF RADIOACTIVE MATERIAL

Radioactivity is removed from a user's inventory when reported for disposal or transfer on a waste disposal form. There are 7 methods for "disposal" - decay, release to the sanitary sewer (aqueous liquids), exhaust to the atmosphere (volatilization in a hood), administration to patients (medical users only), disposal to the health physics staff (Safety Department pickup service), transfer to another authorized user (on-campus), and transfer to another licensee (off-campus).

NOTE: Authorized users may not burn radioactive waste in any UW incinerator.

A. Cardinal Rules for Radioactive Waste Disposal

Low level radioactive waste disposal is expensive and existing disposal space limited. The following requirements help maximize disposal options and minimize costs. Follow these rules when collecting and preparing wastes for disposal.

1. Minimize radioactive waste volumes - keep non-radioactive wastes separate from radioactive wastes, pack waste efficiently and, whenever possible, clean/recycle reusable "wastes" (e.g. glassware).
2. Keep waste types separate - solids, aqueous liquids, organic solvents, LSC wastes and animals.
3. Except for H-3 and C-14, which may be mixed, keep radionuclides separate whenever possible.
4. Package concentrated "hot" wastes in small containers separate from relatively dilute, voluminous "cold" wastes.
5. To the extent possible, don't mix radioactivity with other hazardous materials (hazardous wastes, infectious agents, biohazards, pyrophorics, etc.).

B. Disposal to the Health Physics Staff

Safety provides five gallon carboys for aqueous and organic H-3, C-14 and S-35 wastes. Labelled boxes for all solid wastes will be available through Safety on a trial basis. All other waste containers must be provided by users.

Prepare and package the waste according to the waste type in steps 1-4. Follow steps 5-8 for final preparation of all wastes for pickup. Wastes will NOT be picked up, or will be returned, if improperly prepared. Authorized users must correct waste disposal inadequacies before additional pickups will be made.

1. SOLIDS

Place solid wastes in a plastic bag, seal and put in a labelled radioactive waste box. Plastic bags and boxes are currently provided by Safety and must be used for ALL solid wastes; alternates may be used if approved. There is a 20 lb limit for each box.

SIZE	DIMENSIONS W * L * H	VOLUME (ft3)	USE
Small	6" * 6" * 4"	0.1	Concentrated solids or liquids < 50 ml
Medium	12" * 15" * 15"	1.5	Contaminated solids
Large	24" * 15" * 15"	3.0	Contaminated solids

a. Use strong packaging tape to secure the bottom of these boxes.
b. Package and seal sharps (syringes, blades, etc.) inside an impenetrable container before adding to the other waste.
c. Package small volume, concentrated wastes (e.g. stocks, hot products or wastes, sealed sources, etc.) into small boxes separate from large volumes of dilute, contaminated wastes.
d. Do NOT put lead pigs in solid waste boxes unless needed to shield very hot, concentrated wastes in small boxes ONLY. Monitor and dispose of uncontaminated lead in a separate box.
e. Also follow steps 5-8 beginning on page 4.

2. LIQUIDS

Keep aqueous and organic solvent wastes separate and collect in plastic or shatter-proof glass containers, at least 500 ml but not more than 4 liters; use an appropriate size for the actual waste volume. Five gallon carboys may be used for large volumes of dilute H-3, C-14 or S-35 liquids (see activity limits below); carboys are delivered during waste pickups when requested.

CARBOY SHAPE	WASTE TYPE	ACTIVITY LIMITS (mCi) H-3	C-14	S-35*
Round	Organic	2	2	2
Square	Aqueous	- - 20 - -		2

*Do NOT mix S-35 with H-3 or C-14

NOTE: Very concentrated wastes (e.g. stocks), not exceeding 50 ml, should NOT be diluted and need not be neutralized. Tightly seal vials and package separately in the SMALL radioactive waste box.

a. Neutralize aqueous liquids: $5.5 \leq pH \leq 8.5$.
b. Do <u>not</u> put solids in liquid waste containers.
c. Do <u>not</u> fill containers to the top; allow room for thermal expansion.
d. Seal containers securely (do not use parafilm, foil, etc.).
e. Complete and attach a waste identification tag to EACH container > 50ml.
f. Cushion and place containers into boxes (any strong box will do), not more than 4 bottles/box. Safety's 5 gallon carboys need not be boxed.
g. Also follow steps 5-8 beginning on page 4.

3. <u>LSC WASTES</u>
Sewer disposable LSC solutions may be poured directly to the sewer (see Disposal to the Sanitary Sewer, page 5). For pickup by Safety, sewer disposable LSC solutions may either be poured into aqueous liquid containers (see above) or kept in their vials and repackaged in cases. Organic hydrocarbon cocktails (e.g. toluene, xylene, pseudocumene) must be kept in their original counting vials for Safety pickup. When disposing of LSC wastes in vials follow these procedures.

NOTE: Total activity per case is typically in the range of 0.1-100 uCi (222,000 - 222,000,000 dpm) or less.

a. Keep organic hydrocarbon cocktails separate from sewer disposable cocktails.
b. Keep vials separate by size and type (e.g. plastic, glass).
c. Place vials upright in trays and package in full cases only (20 ml vials - 500/case, mini-vials - about 1700/case).
d. On each case mark the LSC brand name and any biological or chemical hazard that might make sewer disposal inappropriate.
e. There is a $6/case disposal charge for sewer disposable cocktails. The disposal charge for organic cocktails will be at the commercial rate (currently about $30-$50/case).
f. Also follow steps 5-8 beginning on page 4.

4. <u>ANIMALS</u>
All animals injected with or administered radioactive materials must be disposed through Safety when sacrificed or expired. Double bag and box all animal tissue and contaminated bedding/waste (Stores stocks these supplies).

ITEM	STORES #	SIZE
Box	4357	23.5"L * 17.5"W * 10.8"H
Bag	4403	45 gallon (23" * 17" * 48")
Bag	4404	25 gallon (16" * 14" * 36")

a. Activity limits: (per package) ≤ 15 mCi H-3 and/or C-14
≤ 0.2 mCi Pb-210
≤ 2 mCi any other nuclide
b. Carcasses must be boxed and frozen.
c. Weight limit is 50 lbs/package (larger animals must be sectioned).
d. Blood, urine and feces should be diluted and disposed to the sewer system, (see Disposal to the Sanitary Sewer, page 5).
e. Also follow steps 5-8 below.

Call the Safety Department in advance to discuss any exceptions for animal disposals.

5. Complete the waste label for each solid waste container. Complete a waste tag for each liquid container, case of LSC vials and animal container; tie or tape the tag securely to the container.

> **NOTE: Always report activity as a number with units. Do NOT use "trace" or "less than X". Note other hazardous chemicals including biohazards and toxic materials. STATE PRECAUTIONS.**

a. Measure or estimate the waste activity. The higher the activity, the more precise the estimate must be.
b. Waste activities should be measured whenever possible. Subsample, count, correct for efficiency (cpm to dpm), and convert from specific activity (uCi/ml or uCi/g) to total activity (SA * volume).
c. Correct waste activities for decay when significant (i.e. 20% or more of the original activity); report decay in the lower right corner of the disposal form. Decay graphs for P-32, S-35, Cr-51 and I-125 are in Appendix I.

6. Seal all containers. ALL wastes, except 5 gallon carboys and animal carcasses with exceptions, must be packaged in boxes.

7. Complete the radioactive waste disposal form - use the blue form for animal tissue and the orange form for all other wastes (see Appendix J).

a. One form may be used for all wastes.
b. Attach Safety's copies to a waste container and keep the original for your records.
c. Call the Safety Department for additional disposal forms.
d. Maintain all receipt and disposal records for at least 2 years after final disposal.

8. Call the Safety Department to schedule the waste pickup.
   a. Lock all wastes in the cabinet or freezer on the morning of pickup.
   b. The exposure rate must be ≤ 2 mrem/hr on contact with cabinet or freezer. Wastes that exceed this level must be kept in your lab, then take the waste to the pickup area when called.

NOTE: Radioactive waste pickups are:
Animals-Wednesday and Friday mornings beginning at 8:30 AM
Other-Monday and Wednesday afternoons beginning at 12:30 PM

C. Disposal to the Sanitary Sewer

Authorized users may dispose of up to 2 mCi/year to the sewer for ALL radionuclides combined. This limit may be increased if necessary or practical; authorized users must apply for any exceptions. In addition, radioactive liquids must satisfy the following criteria for disposal to the sanitary sewer:

1. Concentrations must be at or below the specified limits PRIOR TO discharge to the sewer. Keep records of concentrations and activities disposed.

NUCLIDE	CONCENTRATION LIMIT (dpm/ml)	(uCi/liter)
H-3	222,000	100
C-14	44,400	20
P-32	1,110	0.5
S-35	4,440	2
Ca-45	666	0.3
Cr-51	111,000	50
I-125	88	0.04
Others	See Appendix U, p.20-15 through 20-26 (10CFR20 Appendix B, Table I, Column 2)	

2. Neutral: 5.5 ≤ pH ≤ 8.5
3. Aqueous and readily soluble or dispersible in water.

4. Other chemical and biological waste constituents must be safe for sewer disposal (check the Disposal Guide for chemical restrictions).

Always use the lab's designated "hot" sink and run additional water during and after release to flush the drain and pipes. Report releases to the sewer in the lower right corner of the disposal form.

D. Exhausting Radioactive Material to the Atmosphere

Call a health physicist in advance if any procedure may result in a radioactivity release to the atmosphere. Releases to the atmosphere require evaluation of radionuclide air concentrations and special approval of a designated hood. Air monitors are installed in approved hoods for volatile iodine releases (see Section XIII, Part B). Report releases to the atmosphere in the lower right corner of the disposal form.

E. Transfers

Transfers to other authorized users (on-campus) or to other licensees (off-campus) will result in removal of radioactivity from a user's inventory. See Section XV for more information.

Call Radiation Safety for additional radioactive waste disposal information. Disposal information for chemical and hazardous wastes is given in the Disposal Guide for UW-Madison. Copies are available from the Safety Department.

XX. HEALTH PHYSICS INSPECTIONS AND ENFORCEMENT OF UNIVERSITY RADIATION SAFETY COMMITTEE REGULATIONS

A. Inspections

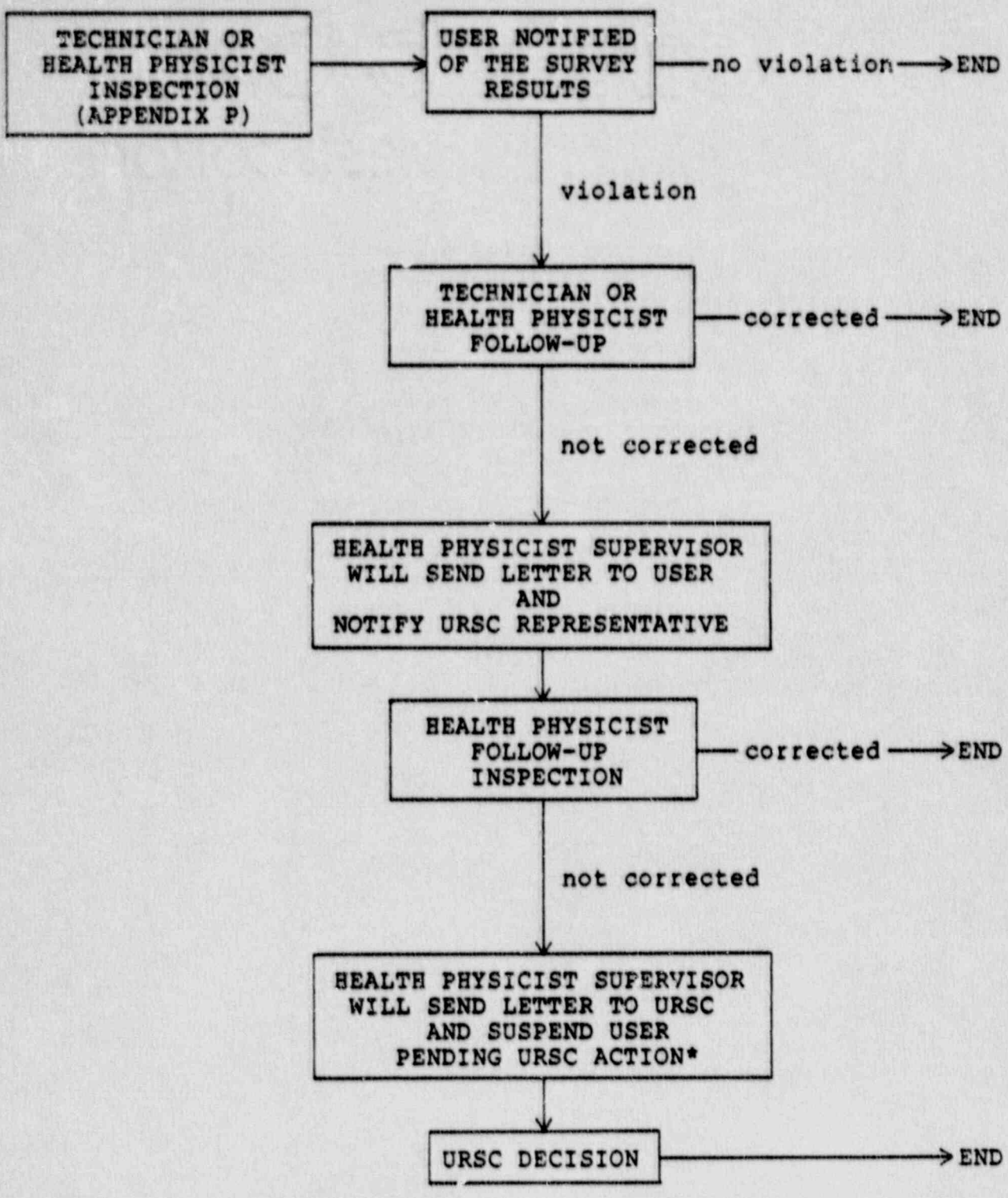
Members of the health physics staff will inspect all radionuclide facilities at least once a year. In addition,

1. Facilities containing large quantities of radioactive materials will be surveyed more frequently.
2. Where violations are found, follow-up surveys will be conducted.

NOTE: Inspections are required to assure compliance with URSC policies, and state and federal regulations.

B. Enforcement of University Radiation Safety Committee Regulations

1. Radiation Safety will inspect (facilities, surveys, inventories, etc.) for compliance. See Appendix P for types of things inspected for.
2. Response to violations is in accordance with the sequence of events on the following page.



* Progression to this step may occur at any stage of the above sequence of events.

SOME BASIC DEFINITIONS AND UNITS

ACCELERATORS - Machines capable of accelerating electrons, protons, deuterons, or other charged particles to produce particulate or other radiation at various energies.

ALARA - Acronym for the radiation protection philosophy that radiation exposures and effluents to the environment should be maintained "As Low As Reasonably Achievable". The NRC requires that ALARA be considered in the design of all experiments where radioactive material is used.

ALPHA (α) PARTICLES - Electrically charged particles emitted from a nucleus. An alpha particle is composed of two neutrons and two protons, and is identical with the nucleus of a helium atom.

AMENDMENT - A written request to change condition(s) (e.g. nuclides, activity limits, labs, etc.) to an authorized user's radionuclide authorization.

AUTHORIZED USER - An individual member of the teaching or research faculty or staff who has been approved by the Radiation Safety Committee to use or supervise the use of radioactive material under conditions specified in an application for authorization. All activities involving radioactive material must be conducted under the authorization of an authorized user.

BETA (β) PARTICLES - Electrically charged particles emitted from a nucleus. Beta particles have the same mass and charge as electrons. Positively charged beta particles are called positrons and emit 0.511 MeV photons when they combine with an electron and annihilate.

BIOASSAY - Monitoring and biological sampling to determine the quantity or concentration of a radionuclide in an individual's body.

BREMSSTRAHLUNG - Electromagnetic radiation in the form of x-rays produced by the sudden deceleration of electrons passing through the intense electric field near an atomic nucleus.

CARBOY - A large glass or plastic bottle, often used to hold corrosive liquids and liquid radioactive waste.

CENTRAL ORDERING, RECEIVING AND DISTRIBUTION (CORD) - The University's major source of radionuclides. CORD personnel perform all the ordering, receiving and distribution of radionuclides on campus.

CONTAMINATION - The presence of radioactive material where it is not supposed to be. A surface is contaminated when levels in excess of ten times background can be detected.

CURIE (Ci) - A physical unit of radioactivity equal to 3.7*E10 disintegrations per second (dps) or 2.22*E12 disintegrations per minute (dpm).

DECAY - The spontaneous transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. The process results in a decrease, with time, of the original radioactive atoms in a sample.

DOSIMETRY - A measure of the external and/or internal radiation dose equivalent to individuals, stated in rem or mrem (0.001 rem).

EXCEPTION - An exemption from any specific University Radiation Safety Committee regulation. Exception requests which violate NRC regulations or conditions of the University's NRC license or URSC policy cannot be approved.

EXEMPT QUANTITY - Radioactive product or byproduct material with activity less than or equal to the quantity listed in 10CFR30.71, Schedule B. Exempt quantities are exempt from specific requirements of the NRC (see Sections III.D, V.A and VII in the University Radiation Safety Regulations).

EXPOSURE HISTORY - A summary report of radiation exposure of a radiation worker for the term of employment, in terms of the dose equivalent received.

FOOD AND DRUG ADMINISTRATION (FDA) - Federal agency established to enforce the Food, Drug, and Cosmetic Act (FD&C Act) and to ensure industry's compliance with Federal laws regulating products in commerce.

GAMMA (γ) RAYS - Electromagnetic radiation of short wavelength emitted from the nucleus of an atom. They are indistinguishable from X-rays of equal energies.

GEIGER-MUELLER (GM) COUNTER - A portable gas-filled radiation detection instrument especially adapted for surveying or inspecting an area to establish the existence and estimate the amount of radioactive material present.

HALF-LIFE - Most commonly used is physical half-life, which refers to the time period that a radioactive substance decays to 50% of its starting activity. The formula to find the activity (A) of a radionuclide with a half-life T at any time (t) after the original activity (Ao) was determined is given by: $A = Ao * \exp(-\ln 2 * t / T)$

INVENTORY - An authorized user's detailed records of receipt, use and disposal of radionuclides.

IONIZING RADIATION - Any radiation displacing electrons from atoms or molecules, thereby producing ions (ultraviolet light is conventionally excluded).

ISOTOPES - Nuclides with the same atomic number (i.e. the same number of protons) but different atomic weights (i.e. different number of neutrons). Tritium is an isotope of hydrogen.

LIMITED QUANTITY - A quantity of radionuclide in activity less than or equal to those listed in 49CFR173.423, that is exempt from all Department Of Transportation (DOT) specification packaging, marking and labeling requirements.

LIQUID SCINTILLATION COUNTER (LSC) - A radiation detection instrument specially adapted to detect the presence of radionuclides which emit beta particles.

MAXIMUM PERMISSIBLE CONCENTRATION (MPC) - The maximum concentration of a radionuclide in air or water which at no time from the onset of constant daily intake, provides a dose equivalent rate to any organ in excess of the maximum permissible dose to that organ.

MAXIMUM PERMISSIBLE BODY BURDEN (MPBB) - The maximum permissible continuous concentration of a radionuclide in a person's body .

MAXIMUM PERMISSIBLE DOSE (MPD) - The maximum dose (equivalent) that the body of a person or specific parts thereof shall be permitted to receive in a stated period of time.

NEUTRON - An uncharged elementary particle found in the nucleus of every atom heavier than Hydrogen (H-1).

NUCLEAR REGULATORY COMMISSION (NRC) - Federal agency established by the Atomic Energy Act of 1954 and the Energy Reorganization Act of 1974 to regulate the use of radioactive material through its Licensing, Inspection and Enforcement, and Standards Development activities.

PLATED SOURCE - Radioactive material permanently deposited on a surface or matrix such that there is no window or other covering between the radioactive material and the open air. Plated sources may contaminate surfaces upon contact.

QUALITY FACTOR (QF) - Linear-Energy-Transfer (LET) dependent factor by which absorbed doses are multiplied to obtain the dose equivalent, a quantity that expresses, on a common scale for all ionizing radiations, the biological effectiveness of the absorbed dose.

RAD - The rad is a measure of the absorbed dose from any ionizing radiation in body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue and also equals 0.01 Gy (Gray) or 0.01 J/kg.

RADIATION AREA - Any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 mrem, or in any 5 consecutive days a dose in excess of 100 mrem.

RADIATION HAZARD - Any condition under which persons might receive a radiation dose in excess of the maximum permissible dose equivalent.

RADIOACTIVE - Any unstable material which spontaneously emits ionizing radiation.

REM - A unit for measuring the dose equivalent to body tissue from any ionizing radiation in terms of its estimated biological effect relative to a dose of one rad of x-rays.
Dose equivalent (rem) = Dose (rad) * Quality Factor
1 Sv (Sievert) = 100 rem

RENEWAL - An application for radionuclide authorization submitted to renew an authorized user's license. This must be done in advance of the expiration date of a current license. (See Section II.B in the University Radiation Safety Regulations.)

RESTRICTED AREA - Any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any area used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

ROENTGEN (R) - A unit of exposure to x- or gamma radiation. One roentgen is equivalent to the production of one electrostatic unit of charge of either sign from interactions in 0.001293 gram of air (1 ml of air under standard conditions). 1 R = 2.58*E-4 Coulomb per kilogram (C/kg) of air.

SEALED SOURCE - Radioactive material permanently enclosed in a capsule designed to prevent leakage or escape of the radioactive material; there is no contact between the radioactive material and the open air.

SOLVENT - Any substance that dissolves other substances.

SURVEY - An evaluation of the radiation hazards incident to the production, use, release, disposal or presence of sources of radiation under a specific set of conditions. Such evaluations include a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive materials present.

TIMELY RENEWAL - The period between the expiration date of a current authorization and the approval date of a renewal authorization during which time an authorized user may continue to use radioactive materials (under conditions in the most current authorization). The renewal application must be submitted by the expiration date of the current authorization.

THERMOLUMINESCENT DOSIMETRY (TLD) - A method of determining radiation dose by using radiation sensitive "crystals" which, when heated, emit a quantity of light that is a function of the amount of radiation the crystals were exposed to.

UNRESTRICTED AREA - Any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. Also, any area used for residential quarters.

UNSEALED SOURCE - Radioactive material in a form other than plated or sealed such that the material is accessible to manipulation by the user. Unsealed sources are capable of contaminating their surroundings.

VIOLATION - A violation of any NRC or URSC regulation or of any condition or limitation of an authorization granted by the URSC.

VOLATILE - A substance capable of evaporating in air as a dust, fume, mist, vapor or gas.

X-RAYS - A form of electromagnetic radiation identical to gamma rays except x-rays originate outside the nucleus of an atom.

APPENDICIES

APPENDIX A-1

UNIVERSITY OF WISCONSIN-MADISON
UNIVERSITY RADIATION SAFETY COMMITTEE MEMBERS
1986-87

Name/Position	Address	Phone No.
F. H. Attix, Vice Chairman Professor of Radiology	1530 MSC	2-2171 2-3527
P. M. DeLuca Prof. of Radiology	Physical Science Lab Stoughton 1530H MSC	873-6651 2-2171
Sue Engelhardt (ex officio) Health Physics Supervisor	Safety Department 317 N. Randall	2-8769 2-0667
M. N. Gould Assoc. Prof. Hs-Med. Rad. Biol.	K4/332 CSC	3-6615
P. A. Helmke Prof. of Soils	163A Soils Bldg.	3-4947
R. B. Inman Prof of Biochemistry-Biophysics	641A Biophysics and Mol. Biology	2-9881
F. C. Larson, M.D. Prof. of Medicine	B4/251 CSC	3-7507
R. J. Nickles Prof. of Radiology	1530A MSC	2-6355
R. R. Radtke (ex officio) Director of Safety	317 N. Randall	2-8769 2-0667
E. E. Seavey Assoc. Director of Animal Care	K4/114 CSC	3-6465
Bruce Thomadsen Assoc. Prof. of Human Oncology	K4/B49 CSC	3-8500
J. W. Tracy, Chairman Asst. Prof. of Vet. Medicine	3158 Vet. Medicine	3-8212 3-8500
W. F. Vogelsang Prof. of Engr. & Nuclear Engr.	143 Mechanical Engr.	2-3374

APPENDIX A-2

UNIVERSITY OF WISCONSIN-MADISON
MEDICAL CENTER RADIATION SAFETY COMMITTEE
1986-87

Name/Position	Address	Phone No.
Sue Engelhardt Health Physics Supervisor	Safety Department 317 N. Randall	2-8769 2-0667
Mike Garvin Program Coordinator, Hsp.Admin.	C5/134 CSC	3-1512
Ronald Laessig Director, State Lab of Hygiene	235A Hygiene Lab Stovall Bldg.	2-1293
F. C. Larson, M.D., Chairman Prof. of Medicine & Pathology	B4/251 CSC	3-7507
R. J. Nickles Prof. of Radiology	1530A MSC	2-6355
S. B. Perlman Asst. Prof. of Nuclear Medicine	DM 239 VA Hospital	125-7014
E. D. Plotka (Marshfield Clinic)	Marshfield Medical Foundation 510 N. St. Joseph Ave. Marshfield, WI 54449	715-387-5241
Robert Radtke Director of Safety	Safety Dept. 317 N. Randall	2-8769 2-0667
Ellis E. Seavey Assoc. Dir. Research Animal Resources Center	K4/114 CSC	3-6465
Bruce Thomadsen Assoc. Prof. of Human Oncology	K4/B49 CSC	3-8500
G. John Weir Nuclear Medicine Marshfield Clinic	1000 N. Oak Ave. Marshfield, WI 54449	
Al Wiley Prof. of Human Oncology	K4/B117 CSC	3-8500
R. D. Woodson, M.D. Assoc. Prof. of Medicine	H4/548 CSC	3-4916
J. R. Cameron Advisor to Committee	1530 MSC	2-9513

Appendix B

APPLICATION FOR POSSESSION AND USE OF RADIONUCLIDES

URSC (031588)
Form 99

EXPIRATION DATE
(Safety Dept. use only)

Complete all applicable items. Refer to the URSR*, or call the Safety Department health physicist for assistance completing this application.

1. Name of applicant(s):_____ _____
   For joint authorizations, underline the name of the individual who will be the principal "authorized user" (for purposes of mailings, ordering radioactive materials, etc.). The information requested on page 4 must be completed for each applicant.

   Campus address:_____Phone:_____

   May we give your name to sales representatives requesting information about radioactive material users? YES____ NO____

2. Check one:

   |__| NEW APPLICATION - Applicant is not currently authorized to possess radionuclides. Complete all items.

   |__| AMENDMENT - Complete only those items which represent a change to your current authorization.

   |__| RENEWAL - Complete all items. Do not make reference to previously submitted information.

3. List all room #(s) and building(s) where radioactive - - - - - - - -

   - materials will be used and/or stored:_____

   - wastes will be stored pending disposal:_____

4. How will security of radioactive materials be maintained when authorized personnel are not present?

   ____ Materials will be stored in a locked cabinet, refrigerator or freezer.
   ____ Room or building will be locked.
   ____ Other (specify)_____
   ____ Not applicable, total radioactivities will not exceed the limits listed in the URSR, Appendix V (e.g. counting labs). List room #(s) and building(s)_____

* URSR - University Radiation Safety Regulations (in yellow 3-ring binder)

5. List each radionuclide and the chemical form(s) below. Generic chemical descriptions (e.g. amino acids, sugars, etc.) may be used.

RADIONUCLIDE	CHEMICAL FORM(S)	PHYSICAL FORM *	ORDER LIMIT** (mCi)	POSSESSION LIMIT*** (mCi)

* Physical Form - solid (S), liquid (L), gas (G) or sealed source (SS)
** Order Limit - the maximum activity needed per unit (vial, kit, etc.)
*** Possession Limit - the maximum activity on inventory at any time

6. Check each intended source for obtaining radionuclides:

☐ CORD - radionuclide ordering service (see URSR, Section III)

☐ UW Cyclotron ☐ VA Hospital Radiopharmacy

☐ UW Reactor ☐ Other (specify)_____

7. Will radioactive materials be administered to or used on humans?
___NO ____YES - complete and submit form 98

8. Will radioactive materials be used in vertebrate animals?
____NO ____YES - complete and submit form 99A

9. Will radioactive materials exceeding the limits listed in the URSR, Appendix V, be used in a class? ____NO ____YES - course #_____

10. Briefly describe your intended use for each radionuclide (e.g. for synthesis, uptake, RIA, etc.) and the media or organisms involved. Iodination protocols are required; add sheets as necessary.

11. Personnel who work in or frequent your radionuclide facilities must read the handbook Radiation Safety for Laboratory Technicians and pass the associated exam (whether they use radioactivity or not). What additional training or instructions will you provide to users?

12. What precautions will be taken to minimize exposures to personnel from radioactivity during use, or while in storage, under your authorization? Radioactivity will be used and/or stored:

____ behind shielding material (describe)_____
_____
____ in a separate room or area not frequented by personnel
____ by personnel wearing appropriate protective attire (e.g. lab coat, disposable gloves, safety glasses, etc.)
____ Other (specify)_____

13. At what frequency will your radionuclide facilities be surveyed?

____ Monthly in rooms where ≥ 200 uCi is in use at any given time (opening a vial, waste container, etc. constitutes use); or semiannually in rooms where lesser activities are used or if radionuclides are in storage only.
____ Other (specify)_____

14. Which of the following will be used to perform surveys for removeable contamination?

____ Wipe tests and liquid scintillation counter.
____ Wipe tests and gamma counter.
____ Other (specify)_____
____ Not applicable, sealed sources only (leak tested by Safety).

15. What instruments will be used to measure radiation exposure rates?

____ *GM survey meter, model(s)_____
____ *Other (specify)_____
*Survey instruments will be calibrated at least annually by:
____ Safety Dept. ____ Other (specify)_____
____ Not applicable, sealed sources or low energy beta use only.

16. What method(s) will be used to dispose of your radioactive wastes?

____ Consolidation (by nuclide and physical form) and proper packaging, etc. for pickup and disposal by the Safety Dept.
____ Dilution to acceptable concentration limits and disposal to the sanitary sewer.
____ Release to the atmosphere in an approved fume hood.
____ Decay
____ Other (specify)_____
____ Waste generation not anticipated.

APPLICANT'S TRAINING AND EXPERIENCE -

Complete a separate sheet for each applicant (make copies if necessary).

TOPICS	WHERE TRAINED	DURATION & TYPE* OF TRAINING
Principles and practices of radiation protection.		
Biological effects of radiation.		
Basic calculations for radioactivity measurement and standardization.		
Instrumentation and monitoring techniques.		
Other (describe) -		

*Type of training means on the job (J) or formal course (C)

EXPERIENCE - Use of radioactive materials, sources, instruments, etc.

RADIONUCLIDE	ACTIVITIES USED (mCi)		TYPE OF USE	DURATION OF EXPERIENCE
	AVG.	MAX.		

Please read before signing :

The applicant agrees to abide by all applicable regulations regarding the use of radionuclides as set forth by the Nuclear Regulatory Commission (NRC), the State of Wisconsin and the University Radiation Safety Committee (URSC) including, but not limited to, the following University Radiation Safety Regulations (URSR):

1. All personnel who work with or in the vicinity of radioactive materials under this authorization, including animal caretakers and students, must be trained in accordance with the URSR, Section V.

2. All personnel must wear dosimeters as required by the URSR, Section VI.B. All personnel using tritium or radioiodine must have urine or thyroid monitoring when required by the URSR, Section XIII.B or XIII.C, as applicable.

3. Any procedure which may result in the production of airborne radioactivity (e.g. as a gas, aerosol, or airborne dust) in activities greater than 10% of the limits given in Appendix V of the URSR, must be carried out under a fume hood or other facilitiy approved by the health physicist. Radioiodine effluents from hoods must be monitored as specified in the URSR, Section XIII.B.

4. All rooms containing radionuclides must be surveyed in accordance with the URSR, Sections IX through XII. All areas must be posted and containers labelled in accordance with the URSR, Section XVII.

5. Records of radionuclide receipt, use and disposal must be kept as specified in the URSR, Section XIV. Radioactive wastes must be disposed in accordance with the URSR, Section XIX.

Applicant's
Signature:_____ Date:_____

University Job Classification:_____

Department:_____

RETURN COMPLETED APPLICATION AND ATTACHMENTS TO: Health Physicist
Safety Department
317 N. Randall Ave.

This application has been reviewed and is recommended for URSC approval for the specified duration, subject to the conditions given below:

Duration of authorization: |__| To expire with current authorization

|__| 3 Years

|__| Other _____

Health Physicist:_____ Date:_____

Comments:

- -

URSC approval is granted in accordance with the information contained in this application, with attachments, and any conditions given below:

URSC Member:_____ Date:_____

Comments:

URSC Chairman:_____ Date:_____
(Approval required for new applicants and non-routine requests only)

Comments:

(URSC 100286)

Form 99a

Animal Use of Radionuclides

1. Complete the table below for each radionuclide-animal experiment you anticipate:

Radionuclide	Animal	Maximum Activity/ Animal	Number of Animals/ Experiment	Time Interval Between Radionuclide Administration and Sacrifice
P-32	gophers	100 μCi	5	24 hr
I-125	Wolverines	10 μCi	12	48 hr

2. Where will the animals be housed for the duration of the experiment(s)?
   _____ In authorized user's laboratory; _____ room
   ___✓___ In animal care facility; ___112___ room
   _____ Other (describe) _____

3. Who will provide care for the animals? (All personnel must have passed the Radiation Safety Exam.)
   _____ Laboratory personnel
   ___✓___ Animal care personnel
   _____ Other (specify) _____

4. How will radioactive animal carcasses and waste be stored pending Safety Department pickup?
   _____ Stored in lab freezer
   ___✓___ Stored in building freezer
   _____ Other (specify) _____

5. Specify survey methods and frequency, including cage surveys:
   Surveys will be done upon completion of each experiment

6. RARC project number V-86 ; V-95

Dr. Bucky W. Badger — December, 1986
Applicant Signature — Date

_____ — _____
Health Physicist — Date

Comments:

_____ — _____
URSC Member — Date

_____ — _____
Chairman, URSC — Date

_____ — _____
Animal Care — Date

Appendix D

AMENDMENT TO RADIONUCLIDE AUTHORIZATION
(USE FOR CHANGES IN RADIONUCLIDE LABORATORIES)

URSC (031588)
Form 99S

_____
EXPIRATION DATE
(Safety Dept. use only)

Name of applicant(s):_____

Campus address:_____ Phone:_____

- **ROOM ADDITIONS :** _____
Room #(s) and building(s) to be added

How will security of radioactive materials be maintained when authorized personnel are not present?

____ Materials will be stored in a locked cabinet, refrigerator or freezer.
____ Room or building will be locked.
____ Other (specify):_____
____ Not applicable, total radioactivities will not exceed the limits listed in the URSR*, Appendix V (e.g. counting lab).

- **ROOM DELETIONS :** _____
Room #(s) and building(s) to be deleted

Do other authorized individuals use radioactivity in the room(s)?

____ NO - Remove all radioactivity, do a final survey (see the URSR*,Section IX.C) and remove all radioactive material signs. ENCLOSE A COPY OF THE FINAL SURVEY(S) WITH THIS AMENDMENT.
____ YES - Room #(s)_____
Remove all of your radioactivity. Final surveys are not necessary for these rooms.

Deleted room(s) will be permanently removed from your authorization.

- **ROOM DEACTIVATIONS :** _____
Room #(s) and building(s) to be deactivated

To "deactivate" a room, i.e. terminate radioactive material use and/or storage in the room for an extended period of time:

____ Remove all radioactivity from the room(s).
____ Survey and decontaminate, if necessary. Keep survey(s).
____ Cover or remove the "radioactive material" signs.

Deactivated rooms will remain on your authorization. Surveys are not required while deactivated. Notify a health physicist before resuming radioactive material use or storage in deactivated rooms.

* University Radiation Safety Regulations

PLEASE SIGN, DATE AND SEND TO: Health Physicist
Safety Department
317 N. Randall Ave.

Please read before signing :

The applicant agrees to abide by all applicable regulations regarding the use of radionuclides as set forth by the NRC, the State of Wisconsin and the University Radiation Safety Committee (URSC). These regulations include, but are not limited to, the following:

1. All personnel who work with or in the vicinity of radioactive materials under this authorization, including animal caretakers and students, must be trained in accordance with the URSR, Section V.

2. All personnel must wear dosimeters as required by the URSR, Section VI.B. All personnel using tritium or radioiodine must have urine or thyroid monitoring when required by the URSR, Section XIII.B or XIII.C, as applicable.

3. Any procedure which may result in the production of airborne radioactivity (e.g. as a gas, aerosol, or airborne dust) in activities greater than 10% of the limits given in Appendix V of the URSR, must be carried out under a fume hood or other facilitiy approved by the health physicist. Radioiodine effluents from hoods must be monitored as specified in the URSR, Section XIII.B.

4. All rooms containing radionuclides must be surveyed in accordance with the URSR, Sections IX through XII. All areas must be posted and containers labelled in accordance with the URSR, Section XVII.

5. Records of radionuclide receipt, use and disposal must be kept as specified in the URSR, Section XIV. Radioactive wastes must be disposed in accordance with the URSR, Section XIX.

Applicant's
Signature:_____ Date:_____

- -

Survey(s) for room deletions done by:_____ Date:_____

This amendment has been reviewed and approved subject to the conditions given below.

Health Physicist:_____ Date:_____

Comments:

- -

URSC approval is granted in accordance with the information contained in this application, with attachments, and any conditions given below. URSC approval is required for room additions only.

URSC Member:_____ Date:_____

Comments:

Appendix E

TEMPORARY TRANSFER OF AUTHORIZATION

URSC (050884)
Form 99T

EXPIRATION DATE
(For Safety Dept. use only)

THIS FORM MAY BE USED TO TEMPORARILY TRANSFER RESPONSIBILITY FOR RADIATION SAFETY IN YOUR FACILITIES TO ANOTHER INDIVIDUAL (REQUIRED FOR ANY ABSENCE IN EXCESS OF 30 DAYS). ASSUME APPROVAL UNLESS OTHERWISE NOTIFIED.

Name of applicant(s): Bucky W Badger
For joint authorizations please underline the primary user's name (for correspondence and mailings, etc.)

Campus address: 101 Camp Randall Phone: 2-8769

Period of Absence: (from) June 1984 (to) January 1985

Authorized user to whom authorization is being temporarily transferred (this individual should have experience with similar nuclides and responsibility for labs in the vicinity of yours): Charles B Oakley

Campus address: 110 Camp Randall Phone: 2-9629

Dr Bucky W. Badger
Applicant's Signature

Dr Charles B Oakley
Substitute User's Signature

This request has been reviewed and approved for consideration by the URSC subject to the conditions listed below:

Health Physicist:_____ Date:_____

The URSC approves of this request in accordance with any conditions listed below:

Duration of authorization: ☐ For the period requested above

☐ Other (specify):_____

URSC Member:_____ Date:_____

APPENDIX F-1

ACCEPTABLE TRAINING AND EXPERIENCE FOR

MEDICAL USES OF BYPRODUCT MATERIAL

[Please note: This material has been taken from NRC Regulatory Guide 10.8, Appendix A: "Guide for the Preparation of Applications for Medical Programs" (January 1979). It is intended for use by the Medical Center Radiation Safety Committee as a guide in the evaluation of physician qualifications for "human use" of radionuclides.]

Paragraph 35.11 (d) of 10 CFR Part 35 provides that the Commission will approve a license application by an institution for medical use of byproduct material if it determines, among other things, that the physician designated as the individual user is adequately trained and experienced in (1) basic radioisotope handling techniques and (2) the clinical use of byproduct material proposed in the application. Similar criteria are established in Paragraph 35.12 (c) of 10 CFR Part 35 for the approval of licenses for medical use of radiopharmaceuticals by individual physicians. Outlined below are training and experience criteria that the Commission, with the assistance of its Advisory Committee on the Medical Uses of Isotopes (ACMUI), has found acceptable for physicians who use radiopharmaceuticals. Each physician's training and experience are examined on a case-by-case basis. If a physician wishes to use radiopharmaceuticals but does not have the training and experience described, he may submit an application listing his specific qualifications and these will be reviewed by the Commission with the assistance of the ACMUI.

1. GENERAL TRAINING

To qualify as adequately trained to use or directly supervise the use of byproduct material listed in Groups I, II, and/or III in Paragraph 35.100 of 10 CFR Part 35, a physician should have:

a. Training in basic radioisotope handling techniques consisting of lectures, laboratory sessions, discussion groups, or supervised experience in a nuclear medicine laboratory in the following areas: (200 hours)

   (1) Radiation physics and instrumentation (100 hours)

   (2) Radiation protection (30 hours)

   (3) Mathematics pertaining to the use and measurement of radioactivity (20 hours)

(4) Radiation biology (20 hours)

(5) Radiopharmaceutical chemistry (30 hours)

(The hours listed next to each of the five subjects above are suggested values and should not be interpreted as specific requirements.)

b. Experience with the types and quantities of byproduct material for which the application is being made, or equivalent (500 hours).

c. Supervised clinical training in an institutional nuclear medicine program (500 hours). The clinical training should cover all appropriate types of diagnostic procedures and should include:

(1) Supervised examination of patients to determine the suitability for radioisotope diagnosis and recommendation on dosage to be prescribed.

(2) Collaboration in calculation of the dose and the actual administration of the dose to the patient, including calculation of the radiation dose, related measurement, and plotting data.

(3) Followup of patients when required.

(4) Study and discussion with preceptor of case histories to establish most appropriate diagnostic procedures, limitation, contraindication, etc.

Note A:

The requirements specified in Sections 1. a, b, and c may be satisfied concurrently in a three month training program IF all three areas are integrated into the program.

Note B:

For each physician named in Item 4 of Form NRC-313M, complete Supplements A and B of Form NRC-313M (Preceptor Statement and the statement of training in basic radioisotope handling techniques). For each subject covered in basic training, state where the training was obtained, the dates, total number of hours, and type of training (e.g., lectures, laboratory sessions).

Alternatives:

Certification by the American Board of Nuclear Medicine will be accepted as evidence that a physician has had adequate training and experience to use Groups I, II, and III.

Certification by the American Board of Radiology in Diagnostic Radiology with Special Competence in Nuclear Radiology will be accepted as evidence that a

physician has had adequate training in basic radioisotope handling techniques and has had adequate clinical experience to use Groups II and III.

2. TRAINING REQUIREMENTS FOR SPECIFIC DIAGNOSTIC PROCEDURES

A physician who wishes to be authorized for only one or two specific diagnostic procedures should have training in basic radioisotope handling techniques and clinical procedures commensurate with the procedures and quantities of byproduct material being requested. Such requests will be examined on a case-by-case basis by the Commission with the assistance of the ACMUI.

3. TRAINING REQUIREMENTS FOR THERAPY PROCEDURES INVOLVING RADIOPHARMACEUTICALS

To qualify as adequately trained to use or directly supervise the use of byproduct material listed in Groups IV and/or V in Paragraph 35.100 of 10 CFR Part 35, a physician should have:

a. Training in basic radioisotope handling techniques (80 hours) including:
   (1) Radiation physics and instrumentation (25 hours)
   (2) Radiation protection (25 hours)
   (3) Mathematics pertaining to the use and measurement of radioactivity (10 hours)
   (4) Radiation biology (20 hours)

   (These requirements are in lieu of, not in addition to, those specified in Section 1.a, above.)

b. Clinical training in specific therapy procedures:

   For Group IV

   (1) Iodine-131 for treatment of hyperthyroidism and/or cardiac conditions:
   Clinical experience in the diagnosis of thyroid function and active participation in the treatment of ten patients.

   (2) Phosphorus-32 for treatment of polycythemia vera, leukemia, and/or bone metastases:
   Treatment of three patients with any combination of these three conditions.

   (3) Colloidal phosphorus-32 intracavitary treatment:
   Active participation in the treatment of three patients.

   For Group V

   (1) Iodine-131 for treatment of thyroid carcinoma:
   Clinical experience in diagnosis of thyroid function and treat-

ment of hyperthyroidism and/or cardiac dysfunction and active participation in the treatment of three patients with thyroid carcinoma.

(2) Colloidal gold-198 for intracavitary treatment:
Active participation in the treatment of three patients.

4. TRAINING REQUIREMENTS FOR THERAPY PROCEDURES INVOLVING SEALED SOURCES

To qualify as adequately trained to use or directly supervise the use of byproduct material listed in Group VI in Paragraph 35.100 of 10 CFR Part 35, a physician should have:

a. Training in basic radioisotope handling techniques (200 hours) consisting of lectures, laboratory sessions, discussion groups, or supervised experience in the following areas:

(1) Radiation physics and instrumentation (110 hours)
(2) Radiation Protection (40 hours)
(3) Mathematics pertaining to the use and measurement of radioactivity (25 hours)
(4) Radiation biology (25 hours)

(The hours listed next to each of the four subjects above are suggested values and should not be interpreted as specific requirements.)

b. Clinical training in specific therapy procedures:

(1) Radiation sources for interstitial, intracavitary, or surface treatment of cancer:
Active practice in therapeutic radiology with a minimum of 3 years experience.

(2) Beta ray applicators for the treatment of superficial eye disease:
Active practice in therapeutic radiology or ophthalmology and experience in the therapeutic use of beta rays or soft X-rays.

Note: Evidence of certification by the American Board of Radiology in Radiology or Therapeutic Radiology, certification as a British "Fellow of the Faculty of Radiology" (FFR) or "Fellow of the Royal College of Radiology" (FRCR), or a Canadian certification from the Royal College of Physicians and Surgeons (RCPS) may be submitted in lieu of the information requested in Sections 4.a and b above.

APPENDIX F-2

URSC
Form 98

APPLICATION FOR "HUMAN USE" OF RADIONUCLIDES
(For details on application procedures, please refer to the section titled "Human Use" in the University Radiation Safety Regulations)

This form must be submitted with Form No. 99

Physicians requesting joint authorizations must submit the information requested in items 1) through 3) for each individual.

1) a. Name of Applicant: Badger (Last) Bucky (First) W. (M.)
(Using physician)

b. Mailing address: 101 Camp Randall

c. Phone: 2-8769 / 2-0607

2) a. Additional information on certification, training and experience:

The applicant named in 1)a is:

i. Licensed to dispense drugs in the practice of medicine or osteopathy in the State of Wisconsin: /✓/ Yes /__/ No
If yes, specify license number: 0000-00

ii. Certified by the American Board of Nuclear Medicine: /✓/ Yes /__/ No

iii. Certified by the American Board of Radiology in Diagnostic Radiology with Special Competence in Nuclear Radiology: /✓/ Yes /__/ No

iv. Certified by the American Board of Radiology in Radiology or Therapeutic Radiology: /✓/ Yes /__/ No

b. The applicant named in 1)a has had the following training and/or experience in radiopharmaceutical chemistry:

Formal Course: /✓/ Yes /__/ No
If yes:

Where: Univ. Madison

When: 1977

No. lecture hours: 300

No. laboratory hours: 300

Experience outside of formal course: /✓/ Yes /__/ No
If yes:

Where: CSC

When: 1977 - present

Duration: continuing

3) Attach documentation of the certification, training and experience indicated in 2).

documentation must be attached

4) Include completed copies of this page for <u>each</u> procedure involving the internal or external administration of radionuclides to humans you wish to be authorized for.

a. Describe the purpose of the procedure, including the specific conditions or diseases to be diagnosed, treated or investigated.

diagnostic

b. Specify the radionuclide(s) to be used (including any present as significant contaminants or impurities) and the chemical and physical form.

this must be specified for each radionuclide

c. Give the proposed dose schedule. For internally administered radioactive material (other than discrete sources), indicate the quantity in millicuries of material; for internal or external irradiation from discrete sources such as cesium implants, cobalt or cesium teletherapy, specify the dose in rems.

must show dose calculations

d. Attach a description, and, where pertinent, sketches of special devices to be used for administering radiation or radioactive material to humans.

must be attached

For <u>each</u> applicant, provide the information requested in 4) e and f on training and experience specific to the procedure described in 4) a - d:

e. Formal Education

Where: UW- Madison

When: 1977

Duration: 300 hours

f. Experience including patient and dose selection and patient followup:

Where: CSC

When: 1977 - present

Duration: continuing

Number of patients treated: 12

5) Will radioactive material for oral or parenteral administration be obtained in prepackaged, precalibrated form from a supplier who manufactures or repackages the product under appropriate pharmaceutical controls related to assay, identity, quality, purity, sterility and nonpyrogenicity?

/✓/ Yes /__/ No /__/ N/A

If no, submit the following with this application:

a. Description of proposed quality control procedures for insuring accurate dose calibration, and verification of identity, quality, sterility, purity and nonpyrogenicity of the material.
b. Description of the instrumentation and calibration procedures for the instrumentation proposed for use in procedures outlined in item 5)a.
c. Identification (by job title and training) of individuals who will hold key positions in procedures given in item 5)a. Describe the administrative and/or technical responsibilities of each.
d. Description of the preparation of colloidal material and the evaluation of nonsealed generators (if applicable).

6) Is it necessary to provide the subject, patient or patient's family with written information regarding the procedure and/or radiation safety concerns before or after the proposed procedure?

/✓/ Yes /__/ No

If yes, please attach copies of the information to be provided by the authorized physician. attach copies as necessary

7) a. Will your proposed use include the non-therapeutic administration of radiation or radionuclides to individuals less than 18 years of age?

/✓/ Yes /__/ No complete as instructed

If yes, submit the information requested in item 7)c i-iii.

b. Will your proposed use include the therapeutic, diagnostic or investigative administration of radiation or radionuclides to pregnant women?

/✓/ Yes /__/ No complete as instructed

i. If yes, submit the information requested in item 7)c i-iii
ii. If no, attach a description of the steps you propose to take in order to insure that the administration of radiation or radionuclides to pregnant women is avoided

c. Additional information required if 7)a or 7)b are answered in the affirmative:

i. Justification for administration of radionuclides or radiation
ii. Special precautions which will be exercised in order to reduce the radiation dose to patient to lowest reasonable level
iii. Calculations of the maximum radiation doses delivered to the whole body, to the critical organ(s) and, where pertinent, to the fetus. For oral and parenteral administrations, these calculations shall include information on:
   - the expected half-life in the various organs
   - the relationship between the radionuclide and the permissible body burden for occupational exposure (except for therapeutic administrations)
   - the rationale for using the dose selected

- the radiation dose due to other simultaneous or accompanying administration of radionuclides or radiation (including X-rays)
- the assumptions used in the worst case dose calculations and the sources of biological distribution data for the radionuclide(s) of interest

8) Will your proposed use include any non-routine medical uses of radiation or radionuclides? (Non-routine medical uses include all human uses not specified in 10CFR35.) attach required information

/☑/ Yes /__/ No

If yes, submit a research protocol including the elements listed in 8)a through f below.

a. Title of study.
b. Description of the purpose for conducting the study.
c. Information on the pharmacological dose (for oral or parenteral administration only).
   i. Active ingredient(s)
   ii. Maximum quantity to be administered to any subject (if the same active ingredient(s) might be simultaneously administered to the subject for another purpose, specify the total quantity). Pharmacological dose calculations are to be based on data from published literature or valid human studies
d. Information on the absorbed dose due to external or internal administration of radiation or radionuclides. For i through iii, the information provided must take into account the effects of all radiation and radionuclides administered including the efects due to impurities or contaminants which may be present and those due to accompanying radionuclide or radiation (including X-ray) administration.
   i. The maximum whole body dose
   ii. The maximum dose to critical organs (include information, as appropriate, indicating the assumptions used in the calculations and the sources of biological dirtribution data for the radionuclide(s) of interest)
   iii. For oral or parenteral radionuclide administration, the relationship between the anticipated radionuclide retention and the permissible body burdens for occupationally exposed individuals
   iv. The rationale for using the dose selected
e. Information on the participants in the study.
   i. Anticipated number of subjects
   ii. Age range of subjects
   iii. Description of selection process
   iv. Confirmation that the consent of the subjects, or their representatives, will be obtained prior to participation
f. A description of the plan of investigation in sufficient detail to permit a critical evaluation of the proposed methods. Include the estimated duration of the study.

9) Human use approval

a. This application has been reviewed and approved for consideration by the Medical Center Radiation Safety Committee and/or Radioactive Drug Research Committee, subject to the conditions listed below.

Signed:_____ Date:_____
Health Physicist

Comments:

b. The Medical Center Radiation Safety Committee and/or Radioactive Drug Research Committee grant permission to obtain and use radionuclides in accordance with the statements contained in this application and any conditions listed below.

Signed:_____ Date:_____
F. C. Larson, M.D.
Chairman, Medical Center
Radiation Safety Committee, and
Radioactive Drug Research Committee

Comments:

APPENDIX G

REQUEST AND AUTHORIZATION FOR SERVICES OF THE UNIVERSITY OF WISCONSIN REACTOR

Section A of this form, to be completed by the applicant, supplies information for periodic reactor utilization reports as well as information on specific irradiation services desired.

Section B constitutes authorization for transfer of irradiated material from the Reactor License to the University Byproduct Material License. This authorization is required in addition to approval for radioisotope use as described in the University Radiation Safety Regulations for services which result in radioactive material to be used outside the Reactor Laboratory.

A. APPLICANT

Responsible Staff Member Bucky W. Badger
Department Biochemistry
Persons who may pick up radioisotopes Tom Lawrence, Julie Olund

If service is provided for instruction, number of students involved N/A
Course Number

If service is provided in support of research, please complete the following:

Object of research effort Use of neutron activation analysis for stable tracers in animal nutrition studies

Research supported by: NIH

Number of persons involved 1 Staff. 2 Students.

Reactor Services Desired: (If irradiation or isotope production, complete (a) or (b) below)

(a) Description of irradiation desired Thermal neutron irradiation

(b)

Isotope	Maximum amount produced

Period for which authorization is desired (not to exceed 1 yr.) to

Signature of responsible staff member Bucky W. Badger

B. University Health Physics Office

The applicant in Section A is hereby authorized receipt of the quantities of byproduct material indicated or of the radioisotopes resulting from the irradiation described during the period _____ to_____

Remarks: (Include any restrictions):_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature_____
University Health Physics Office

Member

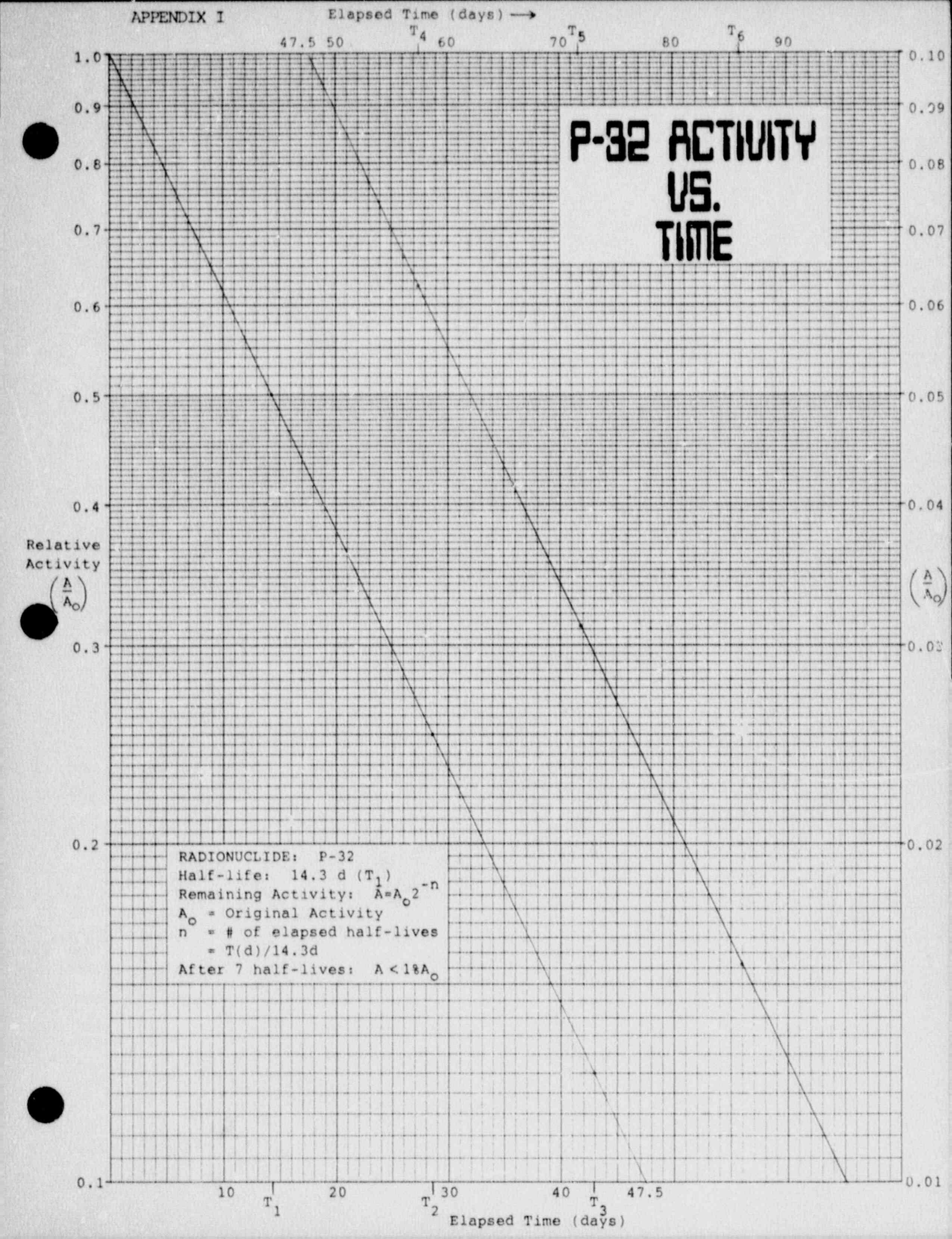
Date:_____

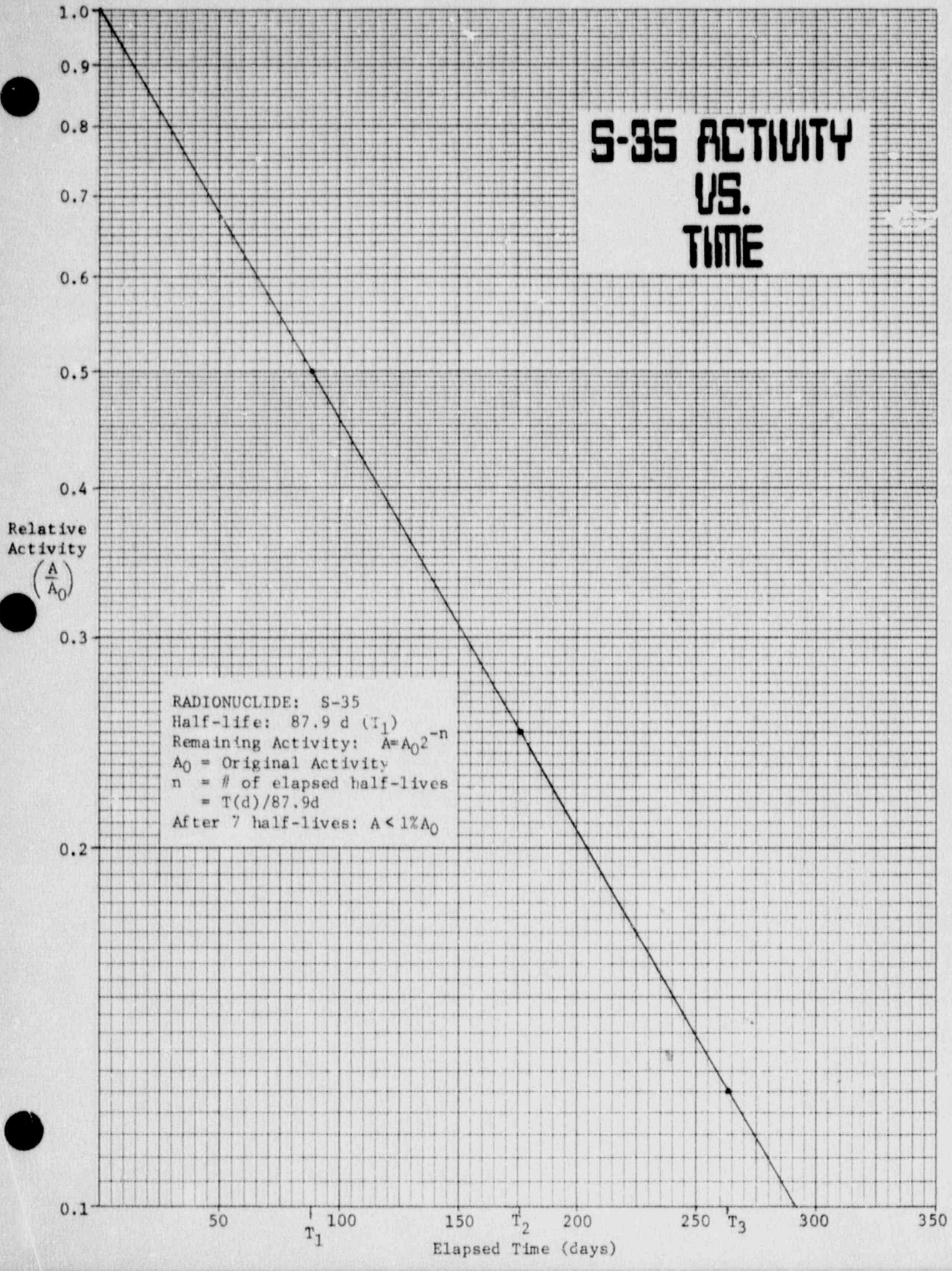
APPENDIX H
NOTIFICATION IN CASE OF RADIATION EMERGENCY

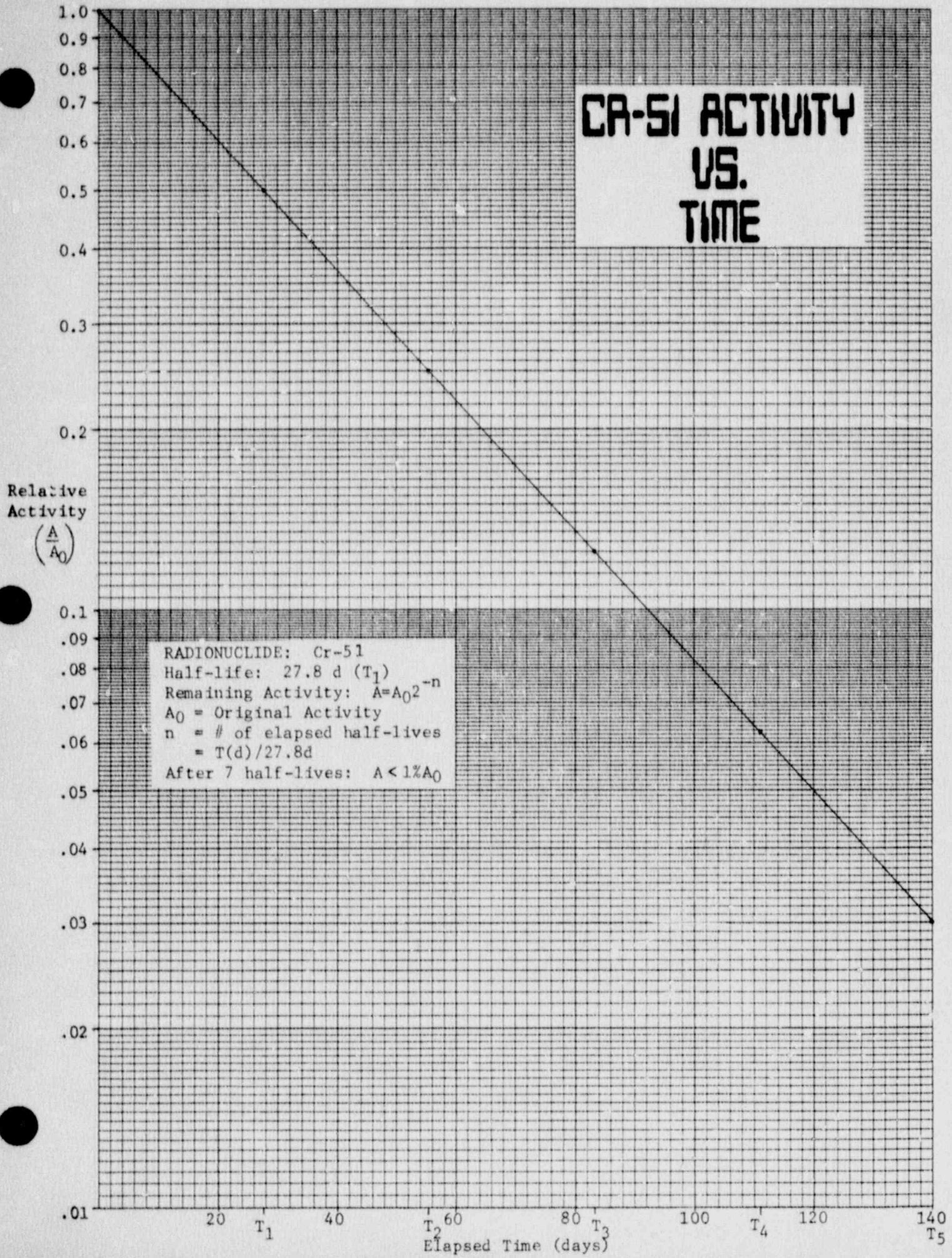
Health Physics Staff	Office Phone	Home Phone
J. Lorenz (Health Physicist)	262-8769/0667	238-7432
L. DeKock (Health Physicist)	262-8769/0667	
D. Kaiser (Health Physicist)	262-8769/0667	256-6277
E. Boeldt (Health Physicist)	262-8769/0667	249-7825
A. Ben-Zikri (Health Physicist)	262-8769/0667	221-1681
S. Engelhardt (Radiation Safety Officer)	262-8769/0667	244-1811
R. Radtke (Director, Safety Department)	262-8769/0667	873-9639
Police and Security	262-2957	
(Call if you cannot reach Health Physics Staff)		
University Radiation Safety Committee Members		
F. H. Attix (Prof. Human Oncology)	262-3527	273-0520
E. E. Seavey (Associate Director of Animal Care)	263-6465	833-2130
R. B. Inman (Prof. of Biochemistry-Biophysics)	262-9881	238-1413
P. M. DeLuca (Prof. Radiology)	873-6651	274-1842
S. J. Engelhardt (Radiation Safety Officer)	262-8769/0667	244-1811
M. N. Gould (Assoc. Prof. Hs-Med. Rad. Biol.)	263-6615	233-6830
P. A. Helmke (Prof. Soils)	263-4947	835-7059
F. C. Larson, M.D. (Prof. Medicine)	263-7507	251-1392
R. J. Nickles (Prof. Radiology)	262-6355	231-3391
R. R. Radtke (Director, Safety Department)	262-8769/0667	873-9639
B. R. Thomadsen (Assoc. Prof. Human Oncology)	263-8500	233-3438
J. W. Tracy (Asst. Prof. Vet. Medicine)	263-8212/8735	437-4822
W. F. Vogelsang (Prof. Engineering)	262-3374	271-1417
Medical Center Radiation Safety Committee Members		
S. J. Engelhardt (Radiation Safety Officer)	262-8769/0667	244-1811
M. L. Garvin (Hospital Safety Director)	263-1512	
R. H. Laessig (Dir. State Lab of Hygiene)	262-1293	238-3034
F. C. Larson, M.D. (Prof. Medicine)	263-7507	251-1392
R. J. Nickles (Prof. Radiology)	262-6355	231-3391
E. D. Plotka (Marshfield Clinic)	(715) 387-5104	
R. R. Radtke (Director, Safety Department)	262-8769/0667	873-9639
E. E. Seavey (Assoc. Dir. Animal Care)	263-6465	833-2130
B. R. Thomadsen (Assoc. Prof. Human Oncology)	263-8500	233-3438
G. J. Weir, Jr., M.D. (Marshfield Clinic)	(715) 387-7787	
A. L. Wiley, M.D. (Prof. Human Oncology)	263-8500	
S. B. Perlman, M.D. (Asst. Prof. Nuclear Medicine)	125-7014	233-3552
R. D. Woodson, M.D. (Prof. Medicine)	263-4916	233-8965
J. R. Cameron (Advisor to Committee)	262-9513	238-2544
If Medical Attention is Needed		
Dr. F. C. Larson	263-7507	251-1392
Dr. S. B. Perlman		
Dr. M. A. Wilson	125-7014	274-8342
Reactor Laboratory		
R. Cashwell (Prog. Supr. Engr., Nuc. Eng.)	262-3392	831-6742
D. Legare (Specialist, Nuc. Engr.)	262-3392	244-4265
S. Matusewic (Prog. Supr. Engr., Nuc. Engr.)	262-3392	832-6264
W. Vogelsang (Professor, Engineering)	262-3374	271-1417

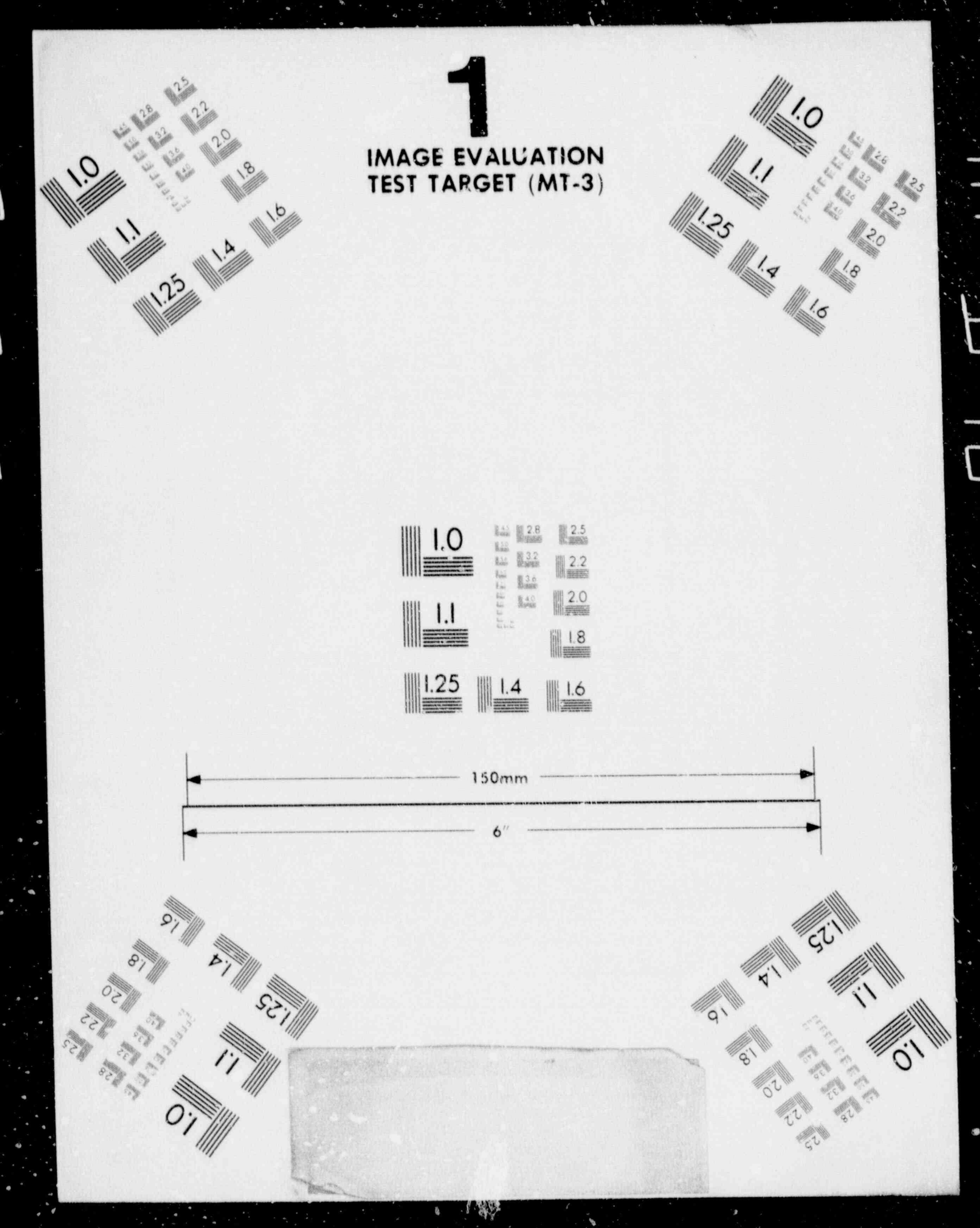
November, 1986

APPENDIX I


Elapsed Time (days) →
47.5 50 T_4 60 70 T_5 80 T_6 90
P-32 ACTIVITY VS. TIME
1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1
0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.02 0.01
Relative Activity $\left(\frac{A}{A_o}\right)$
$\left(\frac{A}{A_o}\right)$
RADIONUCLIDE: P-32
Half-life: 14.3 d (T_1)
Remaining Activity: $A=A_o 2^{-n}$
A_o = Original Activity
n = # of elapsed half-lives
= T(d)/14.3d
After 7 half-lives: $A < 1\% A_o$
10 T_1 20 T_2 30 40 T_3 47.5
Elapsed Time (days)

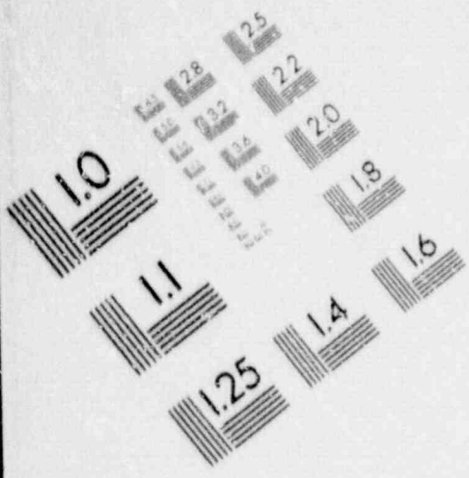

S-35 ACTIVITY VS. TIME
Relative Activity (A/A0)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
RADIONUCLIDE: S-35
Half-life: 87.9 d (T1)
Remaining Activity: A=A0 2-n
A0 = Original Activity
n = # of elapsed half-lives
= T(d)/87.9d
After 7 half-lives: A < 1%A0
50
T1
100
150
T2
200
250
T3
300
350
Elapsed Time (days)

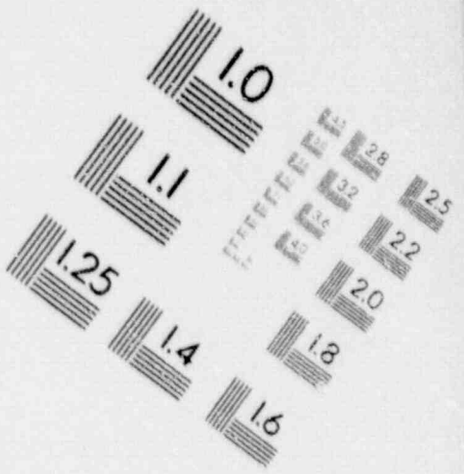

CR-51 ACTIVITY VS. TIME
Relative Activity (A/A0)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
RADIONUCLIDE: Cr-51
Half-life: 27.8 d (T1)
Remaining Activity: A=A0 2^-n
A0 = Original Activity
n = # of elapsed half-lives
= T(d)/27.8d
After 7 half-lives: A < 1%A0
20
T1
40
T2
60
80
T3
100
T4
120
140
T5
Elapsed Time (days)

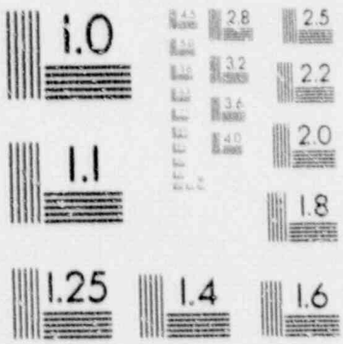

1
IMAGE EVALUATION
TEST TARGET (MT-3)
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
150mm
6"

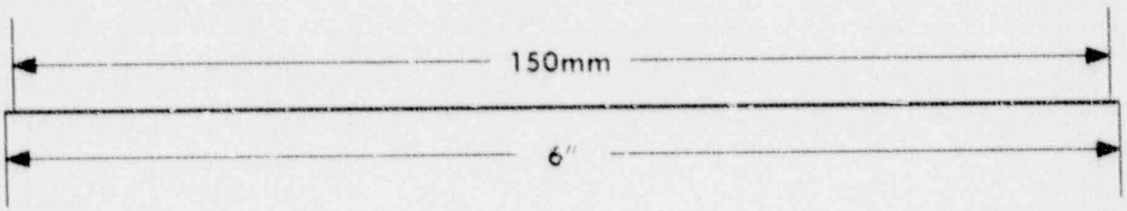
1

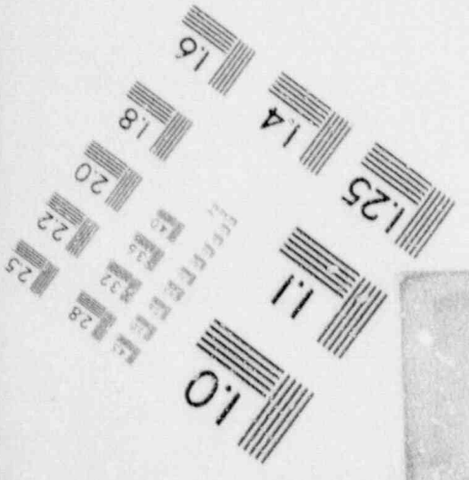
IMAGE EVALUATION TEST TARGET (MT-3)

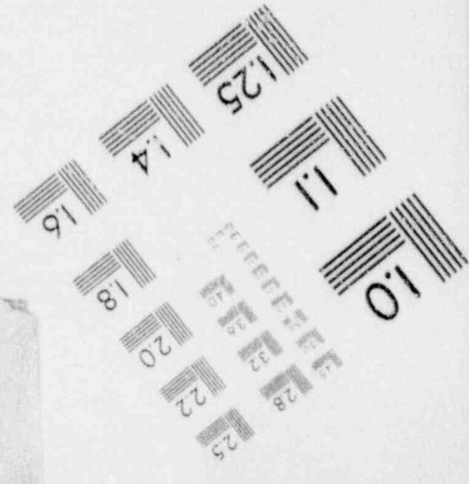


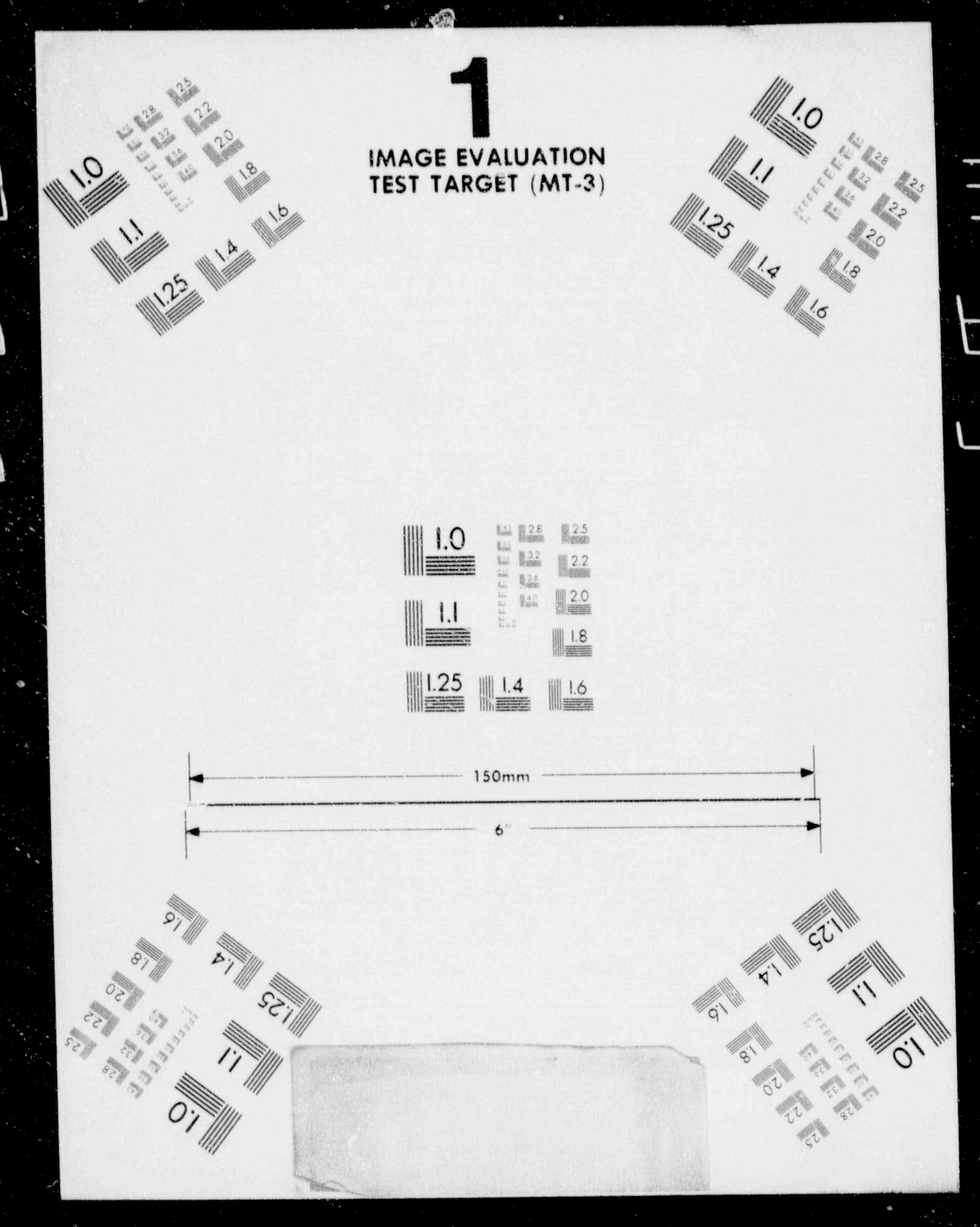


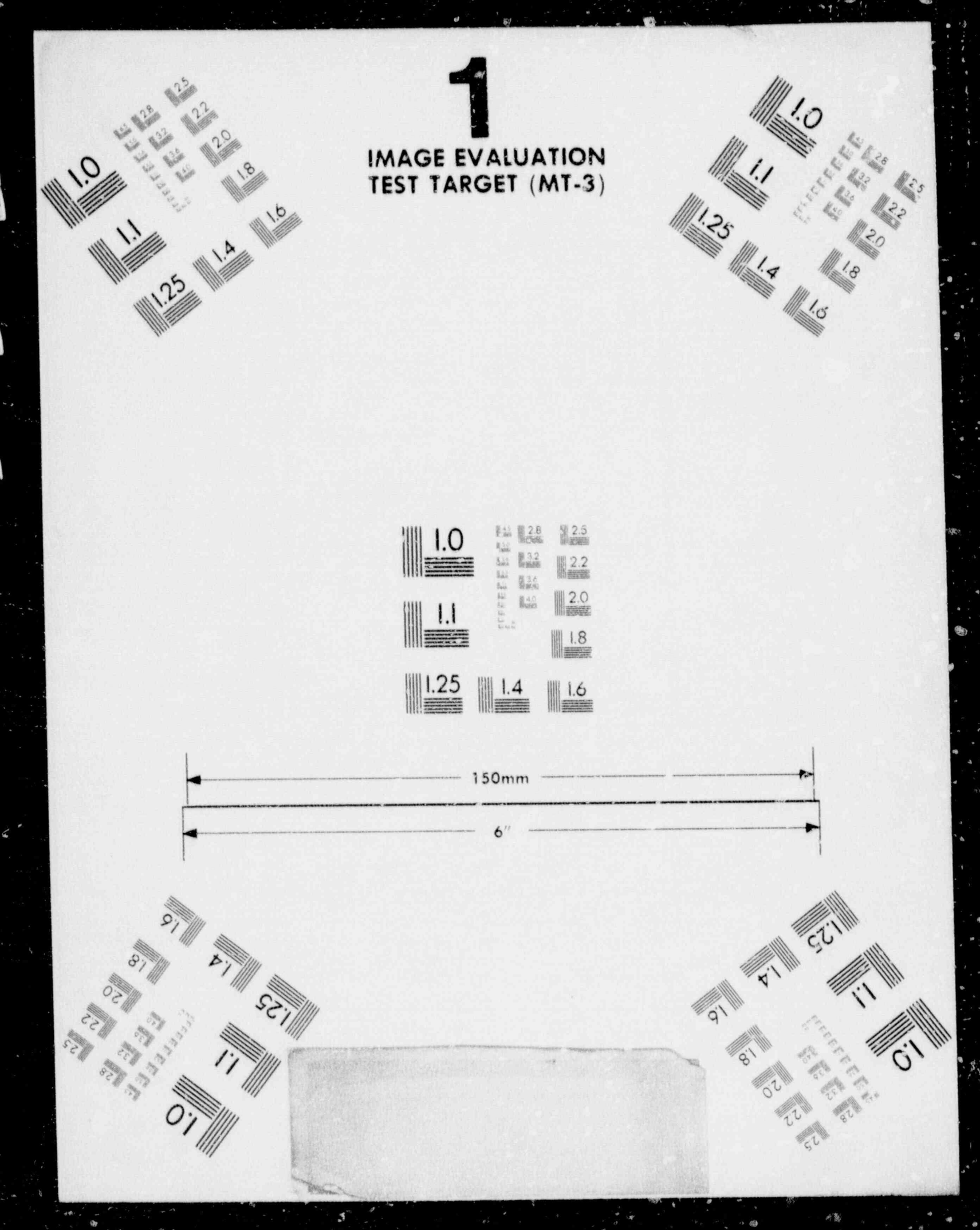




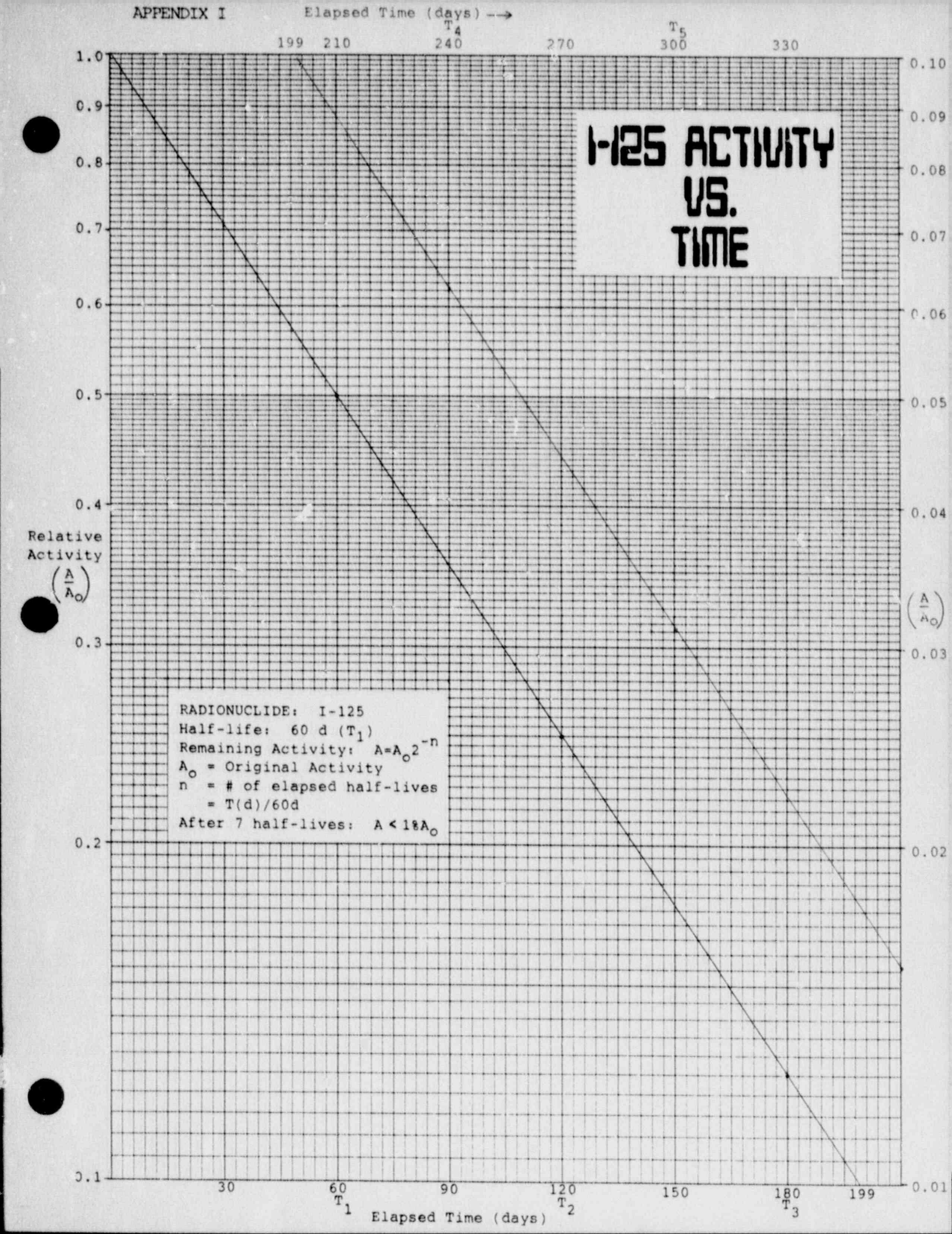





1
IMAGE EVALUATION
TEST TARGET (MT-3)
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
150mm
6"


1
IMAGE EVALUATION
TEST TARGET (MT-3)
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
150mm
6"

APPENDIX I


Elapsed Time (days) →
199
210
T_4
240
270
T_5
300
330
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
Relative Activity $\left(\frac{A}{A_o}\right)$
$\left(\frac{A}{A_o}\right)$
I-125 ACTIVITY VS. TIME
RADIONUCLIDE: I-125
Half-life: 60 d (T_1)
Remaining Activity: $A=A_o 2^{-n}$
A_o = Original Activity
n = # of elapsed half-lives
= T(d)/60d
After 7 half-lives: $A < 1\% A_o$
30
60
T_1
90
120
T_2
150
180
T_3
199
Elapsed Time (days)

RADIOACTIVE WASTE DISPOSAL

APPENDIX J

SAFETY DEPARTMENT (262-8769/0067)

Date: _____ Pickup # _____

Authorized User: _____ Department: _____
Last Name Initials

Person Completing Form: _____ Phone: _____

WASTE TYPE	NUCLIDE	ACTIVITY (mCi)	CHECK APPLICABLE	
			Labware	Radiochemicals (g)
SOLIDS	H-3/C-14	/		
	H-3/C-14	/		

WASTE TYPE		NUCLIDE	ACTIVITY (mCi)	HAZARDOUS CONSTITUENTS (g or l)
LIQUIDS	ORGANIC	H-3/C-14	/	
		H-3/C-14	/	
	AQUEOUS	H-3/C-14	/	
		H-3/C-14	/	

WASTE TYPE	NUCLIDE	ACTIVITY (mCi)	COCKTAIL (specify)	HAZARDOUS CONSTITUENTS (g or l)
LSC VIALS	H-3/C-14	/		
	H-3/C-14	/		
REQ # (for LSC disposal charges):				

INSTRUCTIONS
(PLEASE PRINT ALL INFORMATION)

1. Correct for decay of short-lived nuclides and record below (or record original activity and date at left - for correction at Safety).
2. Neutralize aqueous wastes: $5.5 \leq pH \leq 8.5$
3. Complete the waste identification tag or label for EACH box or liquid container.
4. List EACH waste container on a separate line (i.e., solid box, liquid container >50ml, and full LSC case ----> 500-20ml vials/case, about 1700 mini-vials/case).
5. Record these hazardous constituents, if present:

Acetonitrile	Formalin
Acetophenone	Halogenated Compounds
Acrylamide	Isobutyl Alcohol
Aflatoxins	Metals
Aniline	(e.g., Pb, Hg, Ag, Cr)
Benzene	Methyl Ethyl Ketone
Carbon Disulfide	Nitrosamines
Carbon Tetrachloride	Pesticides
Chlorinated Hydrocarbons	Phenol
	Phthalate Esters
Chloroalkyl Ethers	PCB's
Chloroform	n-Propyl Amine
Dichloromethane	Pyridine & It's Salts
Dioxane	Toluene
Formaldehyde	

Others listed in the UW-Madison *Disposal Guide*

6. Record the pickup no. and date on EACH box.
7. Record other unreported disposals below.
8. Keep ORIGINAL. Attach COPIES to 1 waste container (or mail if no pickup).
9. Call the Safety Department (2-8769/0667) to schedule the pickup.
10. Lock all wastes in the metal cabinets on the morning of pickup. Pickups are Monday and Wednesday afternoons.
NOTE: Dose rate must be ≤2mrem/hr outside cabinet.

See Section XIX in the *University Radiation Safety Regulations* for more information.

OTHER DISPOSAL METHODS

#1 Decay
#2 Sewer Release
#3 Exhausted to the Atmosphere
#4 Administered to Patients
#5 To HP (nonroutine pickup)
#6 Transfer to Another Licensee

METHOD #	NUCLIDE	ACTIVITY (mCi)	DATE

ORIGINAL - Keep for your records.

F-4588d

RADIOACTIVE WASTE DISPOSAL

APPENDIX J

SAFETY DEPARTMENT (262-8769/0067)

Date: _____ Pickup # _____

Authorized User: _____ Department: _____
Last Name Initials

Person Completing Form: _____ Phone: _____

WASTE TYPE	NUCLIDE	ACTIVITY (mCi)	CHECK APPLICABLE	
			Labware	Radiochemicals (g)
SOLIDS	H-3/C-14	/		
	H-3/C-14	/		

WASTE TYPE		NUCLIDE	ACTIVITY (mCi)	HAZARDOUS CONSTITUENTS (g or l)
LIQUIDS	ORGANIC	H-3/C-14	/	
		H-3/C-14	/	
	AQUEOUS	H-3/C-14	/	
		H-3/C-14	/	

WASTE TYPE	NUCLIDE	ACTIVITY (mCi)	COCKTAIL (specify)	HAZARDOUS CONSTITUENTS (g or l)
LSC VIALS	H-3/C-14	/		
	H-3/C-14	/		

REQ # (for LSC disposal charges): _____

ORIGINAL - Keep for your records.

INSTRUCTIONS
(PLEASE PRINT ALL INFORMATION)

1. Correct for decay of short-lived nuclides and record below (or record original activity and date at left - for correction at Safety).
2. Neutralize aqueous wastes: $5.5 \leq pH \leq 8.5$
3. Complete the waste identification tag or label for EACH box or liquid container.
4. List EACH waste container on a separate line (i.e., solid box, liquid container >50ml, and full LSC case ----> 500-20ml vials/case, about 1700 mini-vials/case).
5. Record these hazardous constituents, if present:

Acetonitrile	Formalin
Acetophenone	Halogenated Compounds
Acrylamide	Isobutyl Alcohol
Aflatoxins	Metals
Aniline	(e.g., Pb, Hg, Ag, Cr)
Benzene	Methyl Ethyl Ketone
Carbon Disulfide	Nitrosamines
Carbon Tetrachloride	Pesticides
Chlorinated Hydrocarbons	Phenol
	Phthalate Esters
Chloroalkyl Ethers	PCB's
Chloroform	n-Propyl Amine
Dichloromethane	Pyridine & It's Salts
Dioxane	Toluene
Formaldehyde	

Others listed in the UW-Madison *Disposal Guide*

6. Record the pickup no. and date on EACH box.
7. Record other unreported disposals below.
8. Keep ORIGINAL. Attach COPIES to 1 waste container (or mail if no pickup).
9. Call the Safety Department (2-8769/0667) to schedule the pickup.
10. Lock all wastes in the metal cabinets on the morning of pickup. Pickups are Monday and Wednesday afternoons.
NOTE: Dose rate must be ≤2mrem/hr outside cabinet.

See Section XIX in the *University Radiation Safety Regulations* for more information.

OTHER DISPOSAL METHODS

#1 Decay
#2 Sewer Release
#3 Exhausted to the Atmosphere
#4 Administered to Patients
#5 To HP (nonroutine pickup)
#6 Transfer to Another Licensee

METHOD #	NUCLIDE	ACTIVITY (mCi)	DATE

F-4588d

APPENDIX J

RADIOACTIVE ANIMAL WASTE DISPOSAL

Pickup # _____

Authorized User: _____ Department: _____
Last Name Initials

Person Completing Form: _____ Phone: _____

NUCLIDE	ACTIVITIES (mCi)			RECORD BELOW ANY SPECIAL HANDLING OR INCINERATION INFORMATION
	WASTE	DECAYED	TO SEWER	

INSTRUCTIONS

1. Contaminated blood, urine and feces should be diluted and disposed directly to the sewer system ($\leq$ 2 mCi/year). Report these amounts in the TO SEWER column. Also correct for decay if significant and record in the DECAYED column.
2. Double bag, box, seal and freeze all animals/waste. UW Stores stocks the boxes, #4357, and bags, #4403 or #4404.
3. The weight limit is 50 lbs/container (larger animals must be sectioned).
4. Complete and attach a waste identification label to each animal container.
5. Complete the information above (one form may be used for several containers). PLEASE PRINT.
6. Keep the original for your records; attach Safety's copy to the waste container.
7. Call the Safety Department (2-8769/0667) to schedule the pickup. Pickups start at 8:30 AM on Wednesday and Friday mornings.
8. Lock all wastes in the freezer on the morning of pickup. The exposure rate must be $\leq$ 2 mrem/hr on contact with freezer. Wastes that exceed this level must be kept in your lab freezer; then take the waste to the pickup area when called.

CALL THE SAFETY DEPARTMENT (262-8769/0667) IN ADVANCE TO DISCUSS ANY EXCEPTIONS FOR ANIMAL DISPOSALS.

F-1983d

FORM #316

APPENDIX K

For Dept. use only
#MOE _____ N ☐ P ☐

RADIATION SAFETY EXAMINATION

PLEASE PRINT

Name: Bucky W. Badger Campus Phone #: 2-8769

Social Security #: 000-00-111 Birth Date: March 20, 1970

Classification: Student ☐ Other ☑

List all radionuclides you will be working with (if you will not be working with any radionuclides you need only answer questions 1-20):

I-125, F-18, H-3, P-32, reactor products

1. Who is your authorized user? _____

2. ____rays and ____rays are high energy electromagnetic waves (similar to light).

3. After two half-lives of any given radionuclide, what fraction of the original activity will be remaining? _____

4. The unit of absorbed dose (energy deposited per gram of tissue) is the _____.

5. The basic unit used to measure activity is the _____ which is equal to 3.7×10^{10} disintegrations per second.

6. Exposure, the quantity that expresses the ionization produced by gamma or X-rays in air, is measured in units of _____.

7. The three products of radioactive decay are_____,_____and _____. Of these products,_____are generally the most penetrating and _____are generally the least penetrating.

8. Biological damage due to radioactive materials is caused by _____ _____,which is the separation of electrons from atoms.

9. List four low energy beta-emitters which are not an external radiation hazard: _____ _____ _____ _____

10. Persons working with the above low energy beta-emitters (do/do not) _____need to wear a film badge.

11. List two possible natural causes responsible for the continual occurrence of chromosome damage:_____,_____.

12. List three radionuclides which are external hazards if improperly shielded: _____ _____ _____

13. During what part of a pregnancy is the fetus most radiosensitive? _____. What is the NCRP's maximum dose recommendation for an unborn child?_____

14. What is the average accumulated dose for an individual living in the United States for twelve years due to natural background (excluding medical exposures)?_____

RADIATION SAFETY EXAMINATION

15. Radiation exposure can be reduced by increasing or decreasing what three factors (specify increase or decrease)?

_____, _____, _____.

16. Moving twice as far away from a radioactive source reduces the dose by a factor of _____.

17. Four methods of radioactive waste disposal are:

_____ _____

18. In general, objects placed near a sealed source of radioactivity (will/will not) _____ become radioactive.

19. 1500μCi (microcuries) = _____mCi (millicuries).

20. Whom would you notify in the event of a radiation emergency?

_____

Only persons directly involved in handling radionuclides need to answer the remaining questions. Base your answers on the current University Radiation Safety Regulations. Answers to some of these questions may not be found in the handbook "Radiation Safety for Laboratory Technicians".

21. Each authorized user may dispose of a combined total of _____mCi of radioactive materials to the sewer system each calendar year.

22. Who may incinerate radioactive animals and animal wastes on the UW-Madison Campus?_____

23. What radionuclides may be put into the five gallon jugs provided by the Safety Department for disposal as liquid waste for incineration? _____. What is the maximum total activity allowed per jug?_____

24. What is the minimum laboratory survey frequency required of the authorized user in labs where 200 microcuries or more of radionuclides are in use?_____

25. What is the minimum frequency required for survey meter calibration?

_____

26. In what part of a radionuclide laboratory may food and/or beverages be consumed, stored or prepared?_____

I have read the handbook "Radiation Safety for Laboratory Technicians" and completed this examination.

Signed:_____

Date:_____

Each answer space is worth one point. Anyone with six or more incorrect answers will be required to retake the exam. Authorized users will be notified of personnel who have submitted a failed exam.

For additional information, please refer to the Section "Training and Instruction Required for Radiation Workers" in the University Radiation Safety Regulations.

Return the completed exam to: Safety Department
317 N. Randall Avenue

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C. 20555

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

The Nuclear Regulatory Commission (NRC) in its Rules and Regulations: Part 20 has established standards for your protection against radiation hazards from radioactive material under licence issued by the NRC; Part 19 has established certain provisions for the options of workers engaged in NRC licensed activities; Parts 30, 40, 50, and other parts containing provisions related to employee protection.

POSTING REQUIREMENTS. Copies of this notice must be posted in a sufficient number of places in every establishment where activities licensed by the NRC are conducted, to permit employees to observe a copy on the way to or from their place of employment.

YOUR EMPLOYER'S RESPONSIBILITY

Your employer is required to—

1. Apply these NRC regulations and the conditions of his NRC license to all work under the license.
2. Post or otherwise make available to you a copy of the NRC regulations, licenses, and operating procedures which apply to work you are engaged in, and explain their provisions to you.
3. Post Notices of Violation involving radiological working conditions, proposed imposition of civil penalties and orders.
4. Refrain from discriminatory acts against employees who provide information to NRC.

YOUR RESPONSIBILITY AS A WORKER

You should familiarize yourself with those provisions of the NRC regulations, and the operating procedures which apply to the work you are engaged in. You should observe their provisions for your own protection and protection of your co-workers.

WHAT IS COVERED BY THESE NRC REGULATIONS

1. Limits on exposure to radiation and radioactive material in restricted and unrestricted areas.
2. Measures to be taken after accidental exposure;
3. Personnel monitoring, surveys and equipment;
4. Caution signs, labels, and safety interlock equipment;
5. Exposure records and reports;
6. Options for workers regarding NRC inspections;
7. Identifies "protected activities" that employees may engage in;
8. Prohibits discrimination against employees who engage in these protected activities;
9. Identifies the Department of Labor as a source of relief in the event of discrimination; and
10. Related matters.

REPORTS ON YOUR RADIATION EXPOSURE HISTORY

1. The NRC regulations require that your employer give you a written report if you receive an exposure in excess of any applicable limit as set forth in the regulations or in the license. The basic limits for exposure to employees are set forth in Section 20.101, 20.103, and 20.104 of the Part 20 regulations. These Sections specify limits on exposure to radiation and exposure to concentrations of radioactive material in air.
2. If you work where personnel monitoring is required pursuant to Section 20.202;
   (a) your employer must give you a written report of your radiation exposures upon the termination of your employment, if you request it, and
   (b) your employer must advise you annually of your exposure to radiation, if you request it.

INSPECTIONS

All activities under the license are subject to inspection by representatives of the NRC. In addition, any worker or representative of workers who believes that there is a violation of the Atomic Energy Act of 1954, the regulations issued thereunder, or the terms of the employer's license with regard to radiological working conditions in which the worker is engaged, may request an inspection by sending a notice of the alleged violation to the appropriate United States Nuclear Regulatory Commission Regional Office (shown on map below). The request must set forth the specific grounds for the notice, and must be signed by the worker or the representative of the workers. During inspections, NRC inspectors may confer privately with workers, and any worker may bring to the attention of the inspectors any past or present condition which he believes contributed to or caused any violation as described above.

EMPLOYEE PROTECTION

If an employee believes that discrimination has occurred due to engaging in the "protected activities" said employees may, within 30 days of the discriminatory act, file a complaint with the Department of Labor, Employment Standards Administration, Wage and Hour Division. The Department of Labor shall conduct an investigation and shall, where discrimination has occurred, issue an order providing relief to the employee if relief is not provided by other means of settlement.

PROTECTION OF INSPECTORS

The amended Atomic Energy Act, section 235, provides criminal penalties against any individual who kills, forcibly assaults, resists, opposes, impedes, intimidates or interferes with any person who performs any inspections which (1) are related to any activity or facility licensed by the Commission, and (2) are carried out to satisfy requirements under the Atomic Energy Act or under any other Federal law covering the safety of licensed facilities or the safety of radioactive materials. The acts described above are criminal not only if taken against inspection personnel who are engaged in the performance of such inspection duties, but also if taken against inspection personnel on account of such duties.

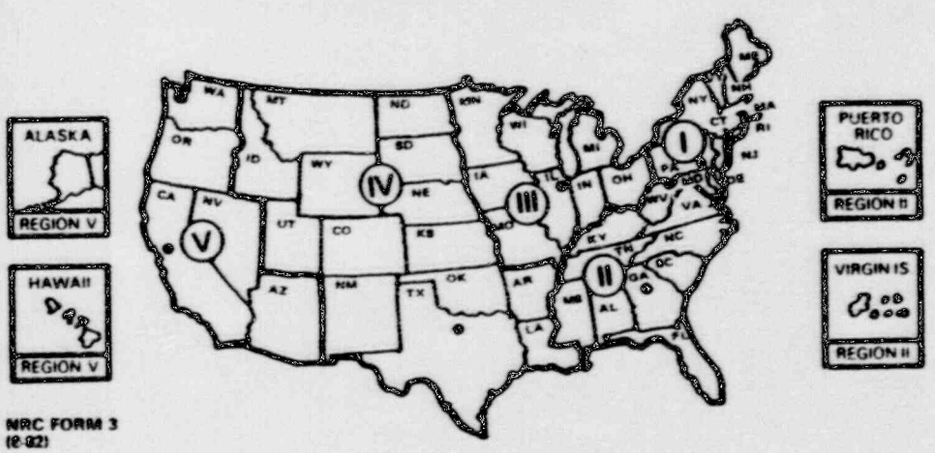
SABOTAGE OF NUCLEAR FACILITIES OR FUEL

The amended Atomic Energy Act, section 236, provides criminal penalties against any individual who intentionally and willfully destroys or causes physical damage, or attempts to do so, to any production, utilization, or waste storage facility licensed under the act, or any nuclear fuel or spent fuel regardless of location.

APPENDIX L

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

A representative of the Nuclear Regulatory Commission can be contacted at the following addresses and telephone numbers. The Regional Office will accept collect telephone calls from employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations.



Regional Offices

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission Region I 631 Park Avenue King of Prussia, PA 19406	215 337-5000
II	U.S. Nuclear Regulatory Commission Region II 101 Marietta St., N.W., Suite 3100 Atlanta, GA 30323	404 221-4500
III	U.S. Nuclear Regulatory Commission Region III 799 Roosevelt Road Glen Ellyn, IL 60137	312-790-5500
IV	U.S. Nuclear Regulatory Commission Region IV 611 Ryan Plaza Drive, Suite 1000 Arlington, TX 76012	817 [illegible]-5100
V	U.S. Nuclear Regulatory Commission Region V 1450 Maria Lane, Suite 210 Walnut Creek, CA 94596	415 943-3700

NRC FORM 3
(8-82)

Appendix M

University of Wisconsin-Madison

SAFETY IS OUR CONCERN...

SAFETY DEPARTMENT
317 N. Randall Avenue
MADISON, WISCONSIN 53715
608 262-8769 - 262-0667

APPLICATION FOR PERSONNEL DOSIMETER

PLEASE PRINT:

Office Use Only	
Date Spare Issued	
Body Dosimeter	
Ring Dosimeter	
Neutron Dosimeter	
Type	
Group No.	
Exam: ___ Yes ___ No ___ N/A	
Ordered	
Permanent Dosimeter No.	
Initials of HP	

1. Name: Badger Bucky W
   Last First Middle or Maiden

2. Birthdate: March 20 1940
   Month Day Year

3. Social Security No. 000-00-1111

4. Campus (work) Phone No. 2-8769

5. Campus (work) Address 101 Camp Randall

6. Have you ever previously been issued a radiation dosimeter at the University of Wisconsin-Madison?

   ✓ Yes ___ No ___ Uncertain

   If yes, please give the name and department of the responsible faculty member, physician or supervisor. T.A. Engels ; Dept. Chemistry

7. a. Circle the current calendar quarter:

   January 15 to April 14, (April 15 to July 14,) July 15 to October 14, October 15 to January 14

   b. Complete the following statement:

   For the current quarter, I have received the following occupational dose due to sources of radiation possessed by individuals or institutions other than the University of Wisconsin-Madison :

   NOTE: If you have been working for the U.W.-Madison during the current quarter, your answer should be ZERO.

   ___ 0 (zero) millirem
   ✓ Other (specify number of millirem) 90

   For doses other than zero, indicate the type of exposure:

   ___ Whole body (Gamma, x-ray)

   ___ Whole body (neutron)

   ___ Skin of whole body (low energy x-rays or beta)

   ✓ Extremities (hands, forearms, feet, ankles)

8. a. Check the statement that applies to you:

✓ I will be working directly with radioactive materials at the University of Wisconsin-Madison.

____ I will be working in a lab where others will use or store radioactive materials. I do not expect to handle radioactive materials myself.

List the major types and quantities of radioactive materials you will be exposed to at any one time.

RADIONUCLIDE	QUANTITY	RADIONUCLIDE	QUANTITY
P-32	1 mCi	F-18	5 mCi
I-125	5 mCi		

b. Check the statement that applies to you (if none apply, see 8.c.):

____ I will be working directly with a machine that produces ionizing radiation (e.g. X-ray diffraction unit, accelerator or chest x-ray unit) at the University of Wisconsin-Madison.

____ I will be working in a lab or facility where others will use a machine that produces ionizing radiation. (I will not use the machine personally.)

List the type(s) of radiation-producing machine(s) you will be exposed to:

_____

_____

c. None of the above applies. I need a badge for the following reason:

_____

_____

9. Who is the faculty member (authorized user) responsible for use of radioactive materials or radiation-producing machine? Bucky W. Badger

What department do you work for? Biochemistry

Who is in charge of badges in your work area? John Olund

Signed: Dr Bucky W. Badger Date: 07 May 1984

Please bring or mail this application to: Safety Department
317 N. Randall Ave.

For more information about badging, refer to the "Personnel Dosimetry" section in the University Radiation Safety Regulations, or call a health physicist at 262-8769.

Form No. 135 (Rev. 6)

APPENDIX N

University of Wisconsin·Madison

SAFETY IS OUR CONCERN...

SAFETY DEPARTMENT
317 N. Randall Avenue
MADISON, WISCONSIN 53715
608 262-8769 - 262-0667

DATE: December 8, 1986

TO: Bucky W. Badger

FROM: John Lorenz
Radiation Safety

RE: Dose Estimate for Lost Radiation Badge

We must have an estimate of the dose you may have received while wearing your lost dosimetry badge. The estimated dose will be added to your exposure history. To properly assign the dose, we need the information requested below. Give specific answers in all the items, epecially numbers 4 and 7. Answers such as "don't know", "very small" or "same as usual" are not acceptable. If estimating your dose, or any other part of the report, causes you problems, call John Lorenz at 262-8769 or 262-0667.

1. Your name: Bucky W. Badger

2. Your Social Security Number: 000-00 1111

3. This estimate is for:

   ✓ Body badge

   _____ Ring badge

4. The monitoring period covered by the lost badge:

   Oct (month) 15 to Nov (month) 14, 1986.

5. What type of radiation were you exposed to?

   a. Machine produced radiation

   ✓ Radiographic x-rays

   _____ Fluoroscopic x-rays

   _____ Other

   For each of the above, list the type and number of procedures you were involved in while wearing the badge.

   5 Chest x-rays

(over)

b. Radiation from radioactive materials

Radionuclide	Activity (mCi)	Total Time Exposed
I-125	2	20 min/procedure x 6 procedures
F-18	5	10 min

c. _____ Other (specify)_____

_____

_____

6. You can use any of the following aids in estimating your dose. Please check any you use in arriving at your estimate.

- ✓ This reading is equal to the highest you have received while performing the same duties.
- _____ This is the same dose reported for others doing the same procedures as yours.
- _____ Area monitors in your work area gave this reading, and the reading for the lost badge is less than or equal to that of the monitors.
- _____ This is a calculated dose (include a summary of how the calculations were done).
- _____ Other (describe)

7. Please estimate the maximum dose you might have received during the period specified in Item 4. If you need help estimating your dose, call John Lorenz at 262-8769 or 262-0667.

Estimate: 30 millirems

Bucky W. Badger
Signature

December 15, 1986
Date

Appendix O

RADIONUCLIDE FACILITY SURVEY

Room Number: 211 Camp Randall

Last User Survey 2/15/88

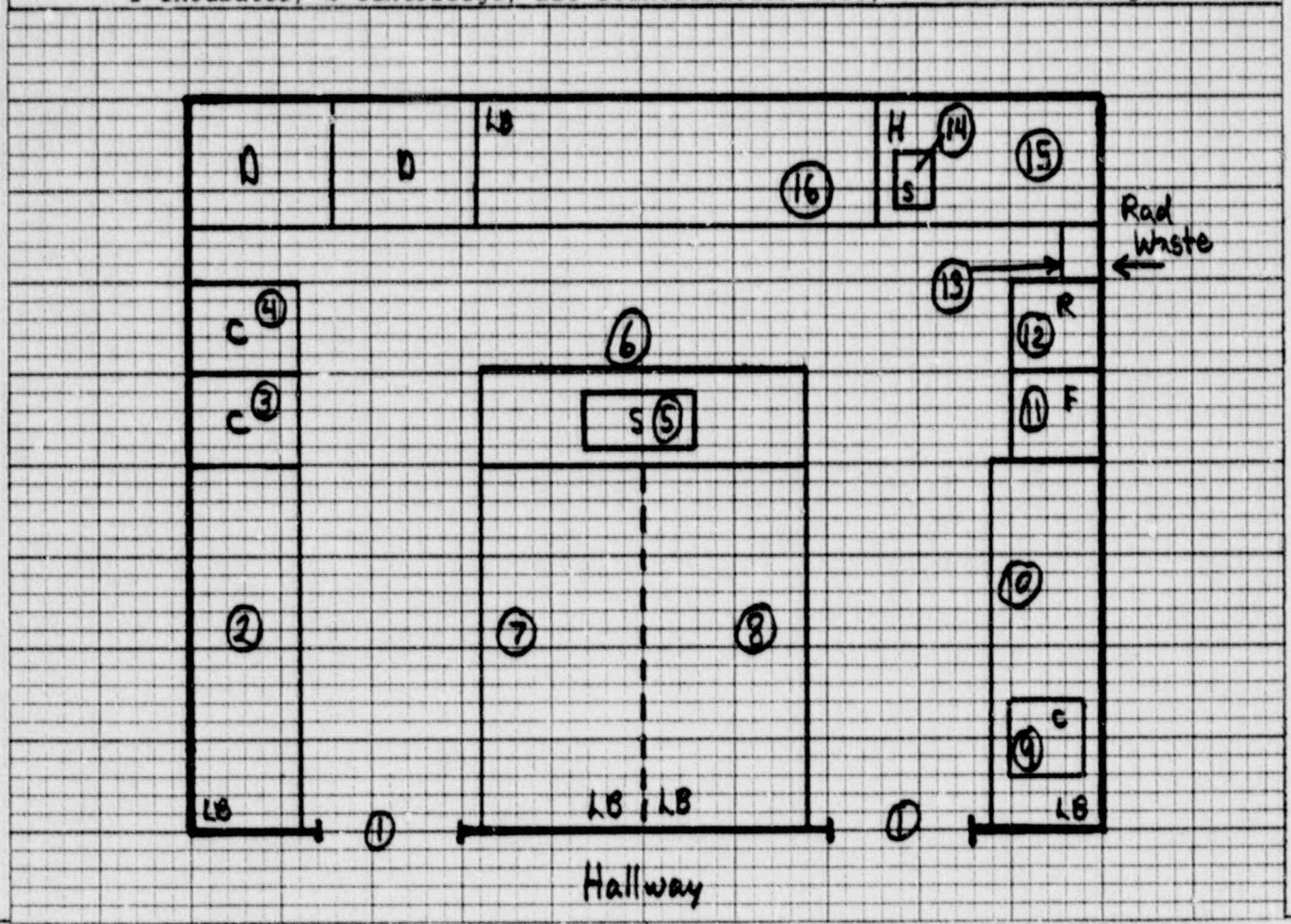
Date: 3/15/88

Violation

Initials: B.B

DETAILED SKETCH OF FACILITY

CODE: LB-Lab Bench; H-Hood; S-Sink; R-Refrigerator; F-Freezer; D-Desk; T-Table; I-Incubator; C-Centrifuge; LSC-Scintillation Ctr.; *-Nuclide Storage



SURVEY METER RESULTS

✓ Eberline E-120 with HP-190(210) probe

___ Other

Background .62 mR/hr

___ NA

All readings background on lower

WIPE TEST RESULTS

✓ Packard LSC (4640)/460

___ Other

Background= 45.0 cpm= _____ dpm

1) 72	9) 66
2) 68	10) 81
3) 70	11) 63
4) 65	12) 61
5) 75	13) 86
6) 99	14) 142
7) 66	15) 1220
8) 51	16) 73

3/16/88 B.J.

Decon + Rewipe #15/84

Background 51

Exceptions List N/A

Verified _____

Decontamination needed? ✓ Yes ___ No #15

Appendix P

FORM #313

RADIONUCLIDE LABORATORY INSPECTION FORM

Health Physics Technician: Sue Smith Date: May 07, 1984

Authorized User: Bucky W. Badger Authorization Expires: 1-87

Office # and Building: 101 Camp Randall Phone: 2-8769

Rad. Safety Tech: Tom Lawrence Phone: 2-0467

AUTHORIZED AREAS FOR NUCLIDES

Storage: 112, 210, 210a, (211) Camp Randall

Use:

Waste:

Other rooms (unauthorized):

Is lab space shared? ___ NO ✓ YES - room(s) and user(s) (circle rooms which need to be surveyed now): 211 with A. Dilman

112 An. Care with Dept.

AUTHORIZED RADIONUCLIDES (in mCi as of May 7 Time: 9:00 a.m.)

Radionuclide:	F-18	H-3	I-125	P-32	Rxtr Prod	Ni-63gc
Present Bal:	10.0	12.5	4.5	2.666		30.0
Order Limit:	20.0	5.0	5.0	1.0		15.0
Poss. Limit:	20.0	20.0	10.0	5.0		30.0

(Recommended survey frequency: every 6 months)

Inventory Status: ___ NOT DUE Date of last inventory:

✓ DUE Inventory Report due back: May 25, 1984

Exceptions to URSC regulations and/or pertinent special conditions:

exception for MF in 210 to be > 10x bkg

Past Contamination? ___NO ✓ YES - Where and when: See past surveys

*Last surveyed by AGR in December '83

✓ Check here if the user was interviewed (required once/year).

VIOLATION	OK	NA	GENERAL
___	✓		Radiation Safety Regulations are current and available to lab personnel.
___	✓		Personnel working in or frequenting labs have taken exam and appear on printout (update printout).
___	✓		Lab personnel are given adequate training in the safe handling and use of radionuclides.
			DOSIMETRY
___	✓	___	Dosimeters are worn when using 1mCi or more of a gamma (body badge only) or high energy beta emitter (body & extremity badges).
___	✓	___	Badged personnel know where dosimetry reports are posted and filed. [Quarterly] Q25 group results in 520 Camp Randall

VIOLATION	OK	NA	
			SURVEYS
___	✓		Frequency of lab surveys: Monthly / 6 monthly Date of last survey: April 25, 1984
___	✓	___	Wipe tests are adequate and documented.
warned ✓	___	___	GM monitoring is adequately thorough and documented.
___	✓	___	Survey meter is calibrated annually. Last calibration date: 12-10-83 ~~Borrowed from:~~ E120/210 # 6002
___	✓	___	Decontaminations are performed and documented.
___	✓	___	Area surveys are done immediately after uses of 5mCi or more of radioiodine/submitted after uses of 50 mCi or more.
___	✓	___	Survey records are maintained for 2 years.
			RECORD KEEPING
___	✓		Receipts, uses and disposals are recorded in a radionuclide log book.
___	✓		Log book is routinely kept up to date.
___	✓	___	Sewer, atmosphere and transfer (NRC exempt) disposals are reported on waste disposal forms. (Date of last transaction H-3 5-1-84)
___	___	✓	If 10 mCi or more of H-3 has been used since last survey, pre and post urine samples have been submitted (check Safety Dept. records) - when and by whom: ___
			OBSERVATIONS
___	✓		Current surveys are posted.
___	✓		Signs are properly posted.
___	✓		NRC-3 is conspicuously posted.
___	✓		Emergency phone #'s are posted by phone(s).
___	✓		Radionuclide storage and waste areas are labelled and secure.
___	✓		Beverages and food are <u>not</u> consumed, stored or prepared in lab.
___	✓		No smoking in lab.
___	✓		No mouth pipetting of radioactive material.
NO	YES	NOT OBSERVED	
___	✓	___	Gloves are worn.
___	✓	___	Lab coats are worn.
___	✓	___	Absorbant paper is used for liquid procedures.

Additional Remarks: 5/7 - All surveys ok.; they forget to document meter surveys once in a while. 5mCi of I-125 not yet used so extra survey not necessary. Good + up to date records. Badge reports kept in 520 Camp Randall [Q25 group]
5/10 Spoke to Dr. Badger + Tom Lawrence about results, discussed importance of documentation + meter surveys.

Who was contacted about the results of this inspection and survey? (The authorized user must be notified directly about violations.)

NAME: Tom Lawrence + Dr. Badger DATE: May 10, 1984

Phone ___
Visit ✓
Mail ___

Appendex Q

RADIOACTIVE MATERIAL RECORD

Date Received: March 15,1988 RSR # 60130

Supplier: NEN Catalog # NEG-009T Lot # 201-7652

Radionuclide: S-35 Chemical: Methionine

Activity/unit: 5 m Ci X 1 (# units) = 5 mCi (Total Activity)

USE INFORMATION					DISPOSAL INFORMATION								
ACTIVITY (µCi or mCi)		VOLUME (µl or ml)		Date & Initials	WASTE TYPES AND ACTIVITY (mCi or µCi)						Waste Pickup #	Date & Initials
Removed	Remaining	Removed	Remaining		Solid	Organic Liquid	Aqueous Liquid	Animal	Other	TOTAL		
.5	4.5	.5	4.5	3/18/88 B.G.								

Instructions:
1) Verify this order is correct and complete the information above; use this record sheet for this material only. You may add sheets to record use and disposal of any new samples, stocks, etc. labelled with this material.
2) Keep these records in a loose leaf binder or central area so they are available to all users.
3) Record use and disposal as they occur, and circle the appropriate volume and activity units. Use the "other" column to record any other disposal methods (e.g. decay, release to the sewer, etc.).
4) The total activity disposed should equal the total used, minus any activity remaining in samples, stocks, etc.
5) This record may be discarded two years after final use of the material, or sooner if approved by a health physics staff member (e.g. after a physical inventory).

Appendix R

University of Wisconsin·Madison

SAFETY IS OUR CONCERN...

SAFETY DEPARTMENT
317 N. Randall Avenue
MADISON, WISCONSIN 53715
608 262-8769 - 262-0667

FORM #322 (111583)

DATE: May 08, 1984

TO: Dr. Bucky W. Badger
101 Camp Randall

FROM:
Health Physicist

RE: PACKAGING REQUIREMENTS FOR SHIPPING RADIOACTIVE MATERIALS

Authorized users, or their personnel, may ship limited quantities of radioactive materials off campus, directly from their labs. However, HEALTH PHYSICIST APPROVAL IS REQUIRED PRIOR TO EACH SHIPMENT (call 262-8769). The health physicist approving the shipment will complete a waste disposal form authorizing the shipment and will send you a copy. Record required documentation on your copy of the disposal form when received (however, you need not wait for the form to ship the material).

The limited quantity (i.e. the maximum activity allowed per package) for the nuclide(s) you requested to ship is:

NUCLIDE	LIMITED QUANTITY* (mCi)	
	liquid form	solid and gas forms
C-14	6	60
H-3	2 (water-1 Ci)	solid-20 gas-20 Ci
I-125	7	70
P-32	3	30
S-35	6	60

*Activity may not exceed the quantity given for the form the radionuclide is in when shipped.

Check with a health physicist if you want to ship any other radionuclides.

The following requirements must be satisfied to comply with DOT regulations for shipping limited quantities of radioactive materials.

- The outside of the inner container must bear the marking "Radioactive".

(OVER)

- The materials must be packaged in strong, tight packages such that there will be no leakage of radioactive material under normal transportation conditions.

- Removable radioactive surface contamination must be determined (and documented) by wipe testing an area not less than 300 square cm and at appropriate locations on the exterior of the package. Call a health physicist if the wipe test is greater than three times background. Removable contamination must not exceed the following specified limits when averaged over the area wiped:

CONTAMINANT	MAXIMUM PERMISSIBLE LIMITS	
	uCi/square cm	dpm/square cm
beta, gamma emitters & nuclides with half-lives < 10 Days	10^{-5}	22
alpha emitters	10^{-6}	2.2

- The radiation level at any point on the external surface of the package must not exceed 0.5 mrem/hr. Document maximum reading.

- The following statement must be included on the packing slip (or on the package) with your name:
"This package conforms to the conditions and limitations specified in 49 CFR 173.421 for excepted radioactive material, limited quantity, n.o.s., UN2910."

If the radioactive material is to be shipped on dry ice, additional requirements must be met.

- A dry ice packaging (e.g. styrofoam liner and outer box) must be used.

- The package must be marked (on one side): DRY ICE
ORM-A
UN1845

- The dry ice and number of pounds must be identified on shipping papers. Most carrier bill of ladings have a space for dry ice identification.

- For each shipment by air exceeding five pounds per package, advance arrangements with each carrier must be made.

If you have any questions about packaging or shipping a limited quantitiy of radioactive material please call me or another health physicist.

November 1975
Revision 1

U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 8.13

OF SAFETY

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12 of 10 CFR Part 19 states that all individuals working in or frequenting any portion of a restricted area must be instructed in the health protection problems associated with exposure to radioactive materials or radiation. This guide describes the instruction that should be provided concerning biological risks to embryos or fetuses resulting from prenatal exposure.*

B. DISCUSSION

Since the Law of Bergonie and Tribondeau was published in 1906** it has been known that the sensitivity of cells to radiation damage is related to their reproductive activity and inversely related to their degree of differentiation. It follows that children could be expected to be more radiosensitive than adults, fetuses more radiosensitive than children, and embryos even more radiosensitive.

This principle has long been a factor in the development of radiation exposure standards. Section 20.104 of 10 CFR Part 20 places different limits on minors than on adult workers. Specifically, it limits anyone under the age of 18 to exposures not exceeding 10% of the limits for adult workers. However, §20.104 does not relate to embryos or fetuses.

A special situation arises when an occupationally exposed woman is pregnant. Exposure of the abdomen of such a worker to penetrating radiation from either external or internal sources would also involve exposure of the embryo or fetus. Because a number of studies have indicated that the embryo or fetus is more sensitive than an adult, particularly during the first three months after conception, when a woman may not be aware that she is pregnant, the National Council on Radiation Protection and Measurements (NCRP) recommended in its Report No. 39 that special precautions be taken to limit exposure when an occupationally exposed woman could be pregnant.

C. REGULATORY POSITION

Instruction to workers performed under §19.12 should be given prior to assignment to work in a restricted area. In providing instruction about health protection problems associated with radiation exposure, female workers and those who may supervise or work with them should be given specific instruction about prenatal exposure risks to the developing embryo and fetus.

The instruction should ensure that the employees understand:

1. That the NCRP has recommended that, during the entire gestation period, the maximum permissible dose equivalent to the fetus from occupational exposure of the expectant mother should not exceed 0.5 rem and

2. The reasons for this recommendation.

The instruction should include the information provided in the Appendix to this guide. It should be presented to the employee, her supervisors, and her co-workers both orally and in written form. Each individual should be given an opportunity to ask questions, and each individual should be asked to acknowledge in writing that the instruction has been received.

D. IMPLEMENTATION

The purpose of this section is to provide information to licensees regarding the use of this guide.

*This revision of the guide includes minor changes of a clarifying nature incorporated as a result of public comments. No substantive changes have been made.

**_Comptes Rendus des Seances de l'Academie des Sciences_, Vol. 143, pp. 983-985, 1906.

Except in those cases in which the licensee chooses to propose an alternative method for complying with the portion of the Commission's regulations previously specified, the methods described herein should be used immediately to instruct female employees working in or frequenting any portion of a restricted area, and those who may supervise or work with such employees, concerning the health protection problems associated with prenatal radiation exposure.

U.S. NUCLEAR REGULATORY COMMISSION

APPENDIX TO REGULATORY GUIDE 8.13

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

Some recent studies have shown that the risk of leukemia and other cancers in children increases if the mother is exposed to a significant amount of radiation during pregnancy. According to a report by the National Academy of Sciences, the incidence of leukemia among children from birth to 10 years of age in the United States could rise from 3.7 cases in 10,000 children to 5.6 cases in 10,000 children if the children were exposed to 1 rem of radiation before birth (a "rem" is a measure of radiation). The Academy has also estimated that an equal number of other types of cancers could result from this level of radiation. Although other scientific studies have shown a much smaller effect from radiation, the Nuclear Regulatory Commission wants women employees of its licensees to be aware of any possible risk so that the women can take steps they think appropriate to protect their offspring.

As an employee of a Nuclear Regulatory Commission licensee, you may be exposed to more radiation than the general public. However, the Nuclear Regulatory Commission has established a basic exposure limit for all occupationally exposed adults of 1.25 rems per calendar quarter, or 5 rems per year. No clinical evidence of harm would be expected in an adult working within these levels for a lifetime. Because the risks of undesirable effects may be greater for young people, individuals under 18 years of age are permitted to be exposed to only 10 percent of the adult occupational limits. (This lower limit is also applied to members of the general public.)

The scientific organization called the National Council on Radiation Protection and Measurements has recommended that because unborn babies may be more sensitive to radiation than adults, their radiation dose as a result of occupational exposure of the mother should not exceed 0.5 rem. Other scientific groups, including the International Commission on Radiation Protection, have also stressed the need to keep radiation doses to unborn children as low as is reasonably achievable.

All Nuclear Regulatory Commission licensees are now required* to inform all individuals who work in a restricted area of the health protection problems associated with radiation exposure. This instruction would in many cases include information on the possible risks to unborn babies. The regulations also state** that licensees should keep radiation exposures as low as is reasonably achievable. According to the National Council on Radiation Protection and Measurements, vigorous efforts should be made to keep the radiation exposure of an embryo or fetus at the very lowest practicable level during the entire period of pregnancy.

Thus it is the responsibility of your employer to take all practicable steps to reduce your radiation exposure. Then it is your responsibility to decide whether the exposure you are receiving is sufficiently low to protect your unborn child. The advice of your employer's health physicist or radiation protection officer should be obtained to determine whether radiation levels in your working areas are high enough that a baby could receive 0.5 rem or more before birth. If so, the alternatives that you might want to consider are:

(a) If you are now pregnant or expect to be soon, you could decide not to accept or continue assignments in these areas.

(b) You could reduce your exposure, where possible, by decreasing the amount of time you spend in the radiation area, increasing your distance from the radiation source, and using shielding.

(c) If you do become pregnant, you could ask your employer to reassign you to areas involving less exposure to radiation. If this is not possible, you might consider

---

* By Title 10, Part 19 of the Code of Federal Regulations.

**In Title 10, Part 20.

leaving your job. If you decide to take such steps, do so without delay. The unborn child is most sensitive to radiation during the first three months of your pregnancy.

(d) You could delay having children until you are no longer working in an area where the radiation dose to your unborn baby could exceed 0.5 rem.

You may also, of course, choose to:

(e) Continue working in the higher radiation areas, but with full awareness that you are doing so at some small increased risk for your unborn child.

The following facts should be noted to help you make a decision:

1. The first three months of pregnancy are the most important, so you should make your decision quickly.

2. In most cases of occupational exposure, the actual dose received by the unborn baby is less than the dose received by the mother because some of the dose is absorbed by the mother's body.

3. At the present occupational exposure limit, the actual risk to the unborn baby is small, but experts disagree on the exact amount of risk.

4. There is no need to be concerned about sterility or loss of your ability to bear children. The radiation dose required to produce such effects is more than 100 times larger than the Nuclear Regulatory Commission's dose limits for adults.

5. Even if you work in an area where you receive only 0.5 rem per three-month period, in nine months you could receive 1.5 rems, and the unborn baby could receive more than 0.5 rem, the full-term limit suggested by the NCRP. Therefore, if you decide to restrict your unborn baby's exposure as recommended by the NCRP, be aware that the 0.5 rem limit to the unborn baby applies to the full nine-month pregnancy.

The remainder of this document contains a brief explanation of radiation and its effects on humans. As you will see, some radiation is present everywhere and the levels of radiation most employees of Nuclear Regulatory Commission licensees receive are not much larger than these natural levels. Because the radiation levels in the facility where you will be working are required by law to be kept quite low, there is not considered to be a significant health risk to individual adult employees.

Discussion of Radiation

The amount of radiation an individual receives is called the "dose" and is measured in "rems." The average individual in the United States accumulates a dose of one rem from natural sources every 12 years. The dose from natural radiation is higher in some states, such as Colorado, Wyoming, and South Dakota, primarily because of cosmic radiation. There the average individual gets one rem every 8 years.

Natural background radiation levels are also much higher in certain local areas. A dose of one rem may be received in some areas on the beach at Guarapari, Brazil, in only about 9 days, and some people in Kerala, India, get a dose of one rem every 5 months.

Many people receive additional radiation for medical reasons. In 1970, an estimated 212 million X-ray examinations were performed in the United States. The estimated average surface skin dose from one radiographic chest X-ray is 0.027 rem. The estimated average surface skin dose per abdominal X-ray is 0.62 rem.*

Radiation can also be received from natural sources such as rock or brick structures, from consumer products such as television and glow-in-the-dark watches, and from air travel. The possible annual dose from working 8 hours a day near a granite wall at the Redcap Stand in Grand Central Station, New York City, is 0.2 rem, and the average annual dose in the United States from TV, consumer products, and air travel is 0.0026 rem.

Radiation, like many things, can be harmful. A large dose to the whole body (such as 600 rems in one day) would probably cause death in about 30 days, but such large doses result only from rare accidents. Control of exposure to radiation is based on the assumption that any exposure, no matter how small, involves some risk. The occupational exposure limits are set so low, however, that medical evidence gathered over the past 50 years indicates no clinically observable injuries to individuals due to radiation exposures when the established radiation limits are not exceeded. This was true even for exposures received under the early occupational exposure limits, which were many times higher than the present limits. Thus the risk to individuals at the occupational exposure levels is considered to be very low. However, it is impossible to say that the risk is zero. To decrease the risk still further, licensees are expected to keep actual exposures as far below the limits as is reasonably achievable.

*"Pre-Release Report: X-Ray Exposure Study (XES) Revised Estimates of 1964 and 1970 Genetically Significant Dose," February 4, 1975, U.S. Department of Health, Education, and Welfare, Public Health Service, Federal Drug Administration, Bureau of Radiological Health.

The current exposure limits for people working with radiation have been developed and carefully reviewed by nationally and internationally recognized groups of scientists. It must be remembered however, that these limits are for adults. Special consideration is appropriate when the individual being exposed is, or may be, an expectant mother, because the exposure of an unborn child may also be involved.

Prenatal Irradiation

The prediction that an unborn child would be more sensitive to radiation than an adult is supported by observations for relatively large doses. Large doses delivered before birth alter both physical development and behavior in experimentally exposed animals. A report of the National Academy of Sciences states that short-term doses in the range of 10 to 20 rems cause subtle changes in the nerve cells of unborn and infant rats. The report also states, however, that no radiation induced changes in development have been demonstrated to result in experimental animals from doses up to about 1 rem per day extended over a large part of the period before birth.

The National Academy of Sciences also noted that doses of 25 to 50 rems to a pregnant human may cause growth disturbances in her offspring. Such doses substantially exceed, of course, the maximum permissible occupational exposure limits.

Concern about prenatal exposure (i.e., exposure of a child while in its mother's uterus) at the permissible occupational levels is primarily based on the possibility that cancer (especially leukemia) may develop during the first 10 years of the child's life. Several studies have been performed to evaluate this risk. One study involved the followup of 77,000 children exposed to radiation before birth (because of diagnostic abdominal X-rays made for medical purposes during their mother's pregnancy). Another study involved the followup of 20,000 such children. In addition, 1292 children who received prenatal exposure during the bombing of Hiroshima and Nagasaki were studied. Although contradictory results have been obtained, most of the evidence suggests a relationship between prenatal exposure and an increased risk of childhood cancer.

Summary

Occupational exposures to radiation are being kept low. However, qualified scientists have recommended that the radiation dose to an embryo or fetus as a result of occupational exposure of the expectant mother should not exceed 0.5 rem because of possible increased risk of childhood leukemia and cancer. Since this 0.5 rem is lower than the dose generally permitted to adult workers, women may want to take special actions to avoid receiving higher exposures, just as they might stop smoking during pregnancy or might climb stairs more carefully to reduce possible risks to their unborn children.

Bibliography

1. Donald G. Pizzarello and Richard L. Witcofski, *Basic Radiation Biology*, Philadelphia: Lea and Febiger, 1967.

2. National Academy of Sciences – National Research Council, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*, Washington, D.C., November 1972.

3. National Council on Radiation Protection and Measurements, *Basic Radiation Protection Criteria*, NRCP Report No. 39, Washington, D.C., January 15, 1971.

4. United Nations, *Ionizing Radiation: Levels and Effects*, 2 vol., Reports of the United Nations Scientific Committee on the Effects of Atomic Radiation, Report No. A/8725, United Nations, New York, 1972.

5. U.S. Atomic Energy Commission, Division of Technical Information, Understanding the Atom Series:

   Atoms, Nature and Man

   The Genetic Effects of Radiation

   The Natural Radiation Environment

   Your Body and Radiation

UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS
TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS – ENERGY

PART 19

NOTICES, INSTRUCTIONS, AND REPORTS TO WORKERS; INSPECTIONS

Sec.
19.1 Purpose.
19.2 Scope.
19.3 Definitions.
19.4 Interpretations.
19.5 Communications.
19.11 Posting of notices to workers.
19.12 Instructions to workers.
19.13 Notifications and reports to individuals.
19.14 Presence of representatives of licensees and workers during inspections.
19.15 Consultation with workers during inspections.
19.16 Requests by workers for inspections.
19.17 Inspections not warranted; informal review.
19.30 Violations.
19.31 Application for exemptions.
19.32 Discrimination prohibited.

Authority: Secs. 53, 63, 81, 103, 104, 161, 186, 68 Stat. 930, 933, 935, 936, 937, 948, 955, as amended, sec. 234, 83 Stat. 444, as amended (42 U.S.C. 2077, 2093, 2111, 2133, 2134, 2201, 2236, 2282); sec. 201, 88 Stat. 1242, as amended by Pub. L. 94-79, 89 Stat. 413 (42 U.S.C. 5841), Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851).

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273); §§ 19.11(a), (c), (d), and (e) and 19.12 are issued under sec. 161b, 68 Stat. 948, as amended (42 U.S.C. 2201(b)); and §§ 19.13 and 19.14(a) are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

40 FR 8774

§ 19.1 Purpose.

The regulations in this part establish requirements for notices, instructions, and reports by licensees to individuals participating in licensed activities, and options available to such individuals in connection with Commission inspections of licensees to ascertain compliance with the provisions of the Atomic Energy Act of 1954, as amended, Title II of the Energy Reorganization Act of 1974, and regulations, orders, and licenses thereunder regarding radiological working conditions.

47 FR 57446

§ 19.2 Scope.

The regulations in this part appy to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in Parts 30 through 35,40,60,61,70 or 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter.

38 FR 22217

§ 19.3 Definitions.

As used in this part:

(a) "Act" means the Atomic Energy Act of 1954, (68 Stat. 919) including any amendments thereto;

(b) "Commission" means the United States Nuclear Regulatory Commission;

(c) "Worker" means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

47 FR 57446

(d) "License" means a license issued under the regulations in Parts 30 through 35,40,60,61,70 or 72 of this chapter, including licenses to operate a production or utilization facility pursuant to Part 50 of this chapter and licenses to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter. "Licensee" means the holder of such a license.

38 FR 22217

(e) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

§ 19.4 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

40 FR 8774

§ 19.5 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street, NW., Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

36 FR 22217

§ 19.11 Posting of notices to workers.

(a) Each licensee shall post current copies of the following documents: (1) The regulations in this part and in Part 20 of this chapter; (2) the license, license conditions, or documents incorporated into a license by reference, and amendments thereto; (3) the operating procedures applicable to licensed activities; (4) any notice of violation involving radiological working conditions, proposed imposition of civil penalty, or order issued pursuant to Subpart B of Part 2 of this chapter, and any response from the licensee.

(b) If posting of a document specified in paragraph (a) (1), (2) or (3) of this section is not practicable, the licensee may post a notice which describes the document and states where it may be examined.

47 FR 30452

(c) Each licensee and applicant shall post Form NRC-3, (Revision 6-82 or later) "Notice to Employees," as required by Parts 30, 40, 50, 60, 70, 72, and 150 of this chapter.

38 FR 22217

(d) Documents, notices, or forms posted pursuant to this section shall appear in a sufficient number of places to permit individuals engaged in licensed activities to observe them on the way to or from any particular licensed activity location to which the document applies, shall be conspicuous, and shall be replaced if defaced or altered.

(e) Commission documents posted pursuant to paragraph (a)(4) of this section shall be posted within 2 working days after receipt of the documents from the Commission; the licensee's response, if any, shall be posted within 2 working days after dispatch by the licensee. Such documents shall remain posted for a minimum of 5 working days or until action correcting the violation has been completed, whichever is later.

§ 19.12 Instructions to workers.

All individuals working in or frequenting any portion of a restricted area shall be kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area; shall be instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed; shall be instructed in, and instructed to observe, to the extent within the worker's control, the applicable provisions of Commission regulations

and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas; shall be instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of Commission regulations and licenses or unnecessary exposure to radiation or to radioactive material; shall be instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material; and shall be advised as to the radiation exposure reports which workers may request pursuant to § 19.13. The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

§ 19.13 Notifications and reports to individuals.

(a) Radiation exposure data for an individual, and the results of any measurements, analyses, and calculations of radioactive material deposited or retained in the body of an individual, shall be reported to the individual as specified in this section. The information reported shall include data and results obtained pursuant to Commission regulations, orders or license conditions, as shown in records maintained by the licensee pursuant to Commission regulations. Each notification and report shall: be in writing; include appropriate identifying data such as the name of the licensee, the name of the individual, the individual's social security number; include the individual's exposure information; and contain the following statement:

38 FR 22217

This report is furnished to you under the provisions of the Nuclear Regulatory Commission regulation 10 CFR Part 19. You should preserve this report for further reference.

(b) At the request of any worker, each licensee shall advise such worker annually of the worker's exposure to radiation or radioactive material as shown in records maintained by the licensee pursuant to § 20.401(a) and (c).

(c) At the request of a worker formerly engaged in licensed activities controlled by the licensee, each licensee shall furnish to the worker a report of the worker's exposure to radiation or radioactive material. Such report shall be furnished within 30 days from the time the request is made, or within 30 days after the exposure of the individual has been determined by the licensee, whichever is later; shall cover, within the period of time specified in the request, each calendar quarter in which the worker's activities involved exposure to radiation from radioactive materials licensed by the Commission; and shall include the dates and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to § 20.405 or § 20.408 of this chapter to report to the Commission any exposure of an individual to radiation or radioactive material the licensee shall also provide the individual a report on his exposure data included therein. Such report shall be transmitted at a time not later than the transmittal to the Commission.

44 FR 32352

(e) At the request of a worker who is terminating employment in a given calendar quarter with the licensee in work involving radiation dose, or of a worker who, while employed by another person, is terminating assignment to work involving radiation dose in the licensee's facility in that calendar quarter, each licensee shall provide to each such worker, or to the worker's designee, at termination, a written report regarding the radiation dose received by that worker from operations of the licensee during that specifically identified calendar quarter or fraction thereof, or provide a written estimate of that dose if the finally determined personnel monitoring results are not available at that time. Estimated doses shall be clearly indicated as such.

§ 19.14 Presence of representatives of licensees and workers during inspections.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect materials, activities, facilities, premises, and records pursuant to the regulations in this chapter.

38 FR 22217

(b) During an inspection, Commission inspectors may consult privately with workers as specified in § 19.15. The licensee or licensee's representative may accompany Commission inspectors during other phases of an inspection.

(c) If, at the time of inspection, an individual has been authorized by the workers to represent them during Commission inspections, the licensee shall notify the inspectors of such authorization and shall give the workers' representative an opportunity to accompany the inspectors during the inspection of physical working conditions.

(d) Each workers' representative shall be routinely engaged in licensed activities under control of the licensee and shall have received instructions as specified in § 19.12.

(e) Different representatives of licensees and workers may accompany the inspectors during different phases of an inspection if there is no resulting interference with the conduct of the inspection. However, only one workers' representative at a time may accompany the inspectors.

(f) With the approval of the licensee and the workers' representative an individual who is not routinely engaged in licensed activities under control of the license, for example, a consultant to the licensee or to the workers' representative, shall be afforded the opportunity to accompany Commission inspectors during the inspection of physical working conditions.

(g) Notwithstanding the other provisions of this section, Commission inspectors are authorized to refuse to permit accompaniment by any individual who deliberately interferes with a fair and orderly inspection. With regard to areas containing information classified by an agency of the U.S. Government in the interest of national security, an individual who accompanies an inspector may have access to such information only if authorized to do so. With regard to any area containing proprietary information, the workers' representative for that area shall be an individual previously authorized by the licensee to enter that area.

§ 19.15 Consultation with workers during inspections.

(a) Commission inspectors may consult privately with workers concerning matters of occupational radiation protection and other matters related to applicable provisions of Commission regulations and licenses to the extent the inspectors deem necessary for the conduct of an effective and thorough inspection.

(b) During the course of an inspection any worker may bring privately to the attention of the inspectors, either orally or in writing, any past or present condition which he has reason to believe may have contributed to or caused any violation of the act, the regulations in this chapter, or license condition, or any unnecessary exposure of an individual to radiation from licensed radioactive material under the licensee's control. Any such notice in writing shall comply with the requirements of § 19.16(a).

(c) The provisions of paragraph (b) of this section shall not be interpreted as authorization to disregard instructions pursuant to § 19.12.

38 FR 22217

§ 19.16 Requests by workers for inspections.

(a) Any worker or representative of workers who believes that a violation of the Act, the regulations in this chapter, or license conditions exists or has occurred in license activities with regard to radiological working conditions in which the worker is engaged, may request an inspection by giving notice of the alleged violation to the Director of Inspection and Enforcement, to the Director of the appropriate Commission Regional Office, or to Commission inspectors. Any such notice shall be in writing, shall set forth the specific grounds for the notice, and shall be signed by the worker or representative of workers. A copy shall be provided the licensee by the Director of Inspection and Enforcement, Regional Office Director, or the inspector no later than at the time of inspection except that, upon the request of the worker giving such notice, his name and the name of individuals referred to therein shall not appear in such copy or on any record published, released, or made available by the Commission, except for good cause shown.

(b) If, upon receipt of such notice, the Director of Inspection and Enforcement or Regional Office Director determines that the complaint meets the requirements set forth in paragraph (a) of this section, and that there are reasonable grounds to believe that the alleged violation exists or has occurred, he shall cause an inspection to be made as soon as practicable, to determine if such alleged violation exists or has occurred. Inspections pur-

suant to this section need not be limited to matters referred to in the complaint.

§ 19.17 Inspections not warranted; informal review.

(a) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines, with respect to a complaint under § 19.16, that an inspection is not warranted because there are no reasonable grounds to believe that a violation exists or has occurred, he shall notify the complainant in writing of such determination. The complainant may obtain review of such determination by submitting a written statement of position with the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, who will provide the licensee with a copy of such statement by certified mail, excluding, at the request of the complainant, the name of the complainant. The licensee may submit an opposing written statement of position with the Executive Director for Operations who will provide the complainant with a copy of such statement by certified mail. Upon the request of the complainant, the Executive Director for Operations or his designee may hold an informal conference in which the complainant and the licensee may orally present their views. An informal conference may also be held at the request of the licensee, but disclosure of the identity of the complainant will be made only following receipt of written authorization from the complainant. After considering all written and oral views presented, the Executive Director for Operations shall affirm, modify, or reverse the determination of the Director of Inspection and Enforcement or of the appropriate Regional Office and furnish the complainant and the licensee a written notification of his decision and the reason therefor.

(b) If the Director of Inspection and Enforcement or of the appropriate Regional Office determines that an inspection is not warranted because the requirements of § 19.16(a) have not been met, he shall notify the complainant in writing of such determination. Such determination shall be without prejudice to the filing of a new complaint meeting the requirements of § 19.16(a).

38 FR 22217

§ 19.20 Employee protection.

Employment discrimination by a licensee or a contractor or subcontractor of a licensee against an employee for engaging in protected activities under this part or Parts 30, 40, 50, 60, 70, 72, or 150 of this chapter is prohibited.

47 FR 30452

§ 19.30 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Act or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder.

40 FR 8774

A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act or any rule, regulation, or order issued thereunder, or any term, condition or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

38 FR 22217

§ 19.31 Application for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 19.32 Discrimination prohibited.

No person shall on the ground of sex be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity licensed by the Nuclear Regulatory Commission. This provision will be enforced through agency provisions and rules similar to those already established, with respect to racial and other discrimination, under title VI of the Civil Rights Act of 1964. This remedy is not exclusive, however, and will not prejudice or cut off any other legal remedies available to a discriminatee.

40 FR 8774

UNITED STATES NUCLEAR REGULATORY COMMISSION
RULES and REGULATIONS
TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS – ENERGY

PART 20 STANDARDS FOR PROTECTION AGAINST RADIATION

PART 20—STANDARDS FOR PROTECTION AGAINST RADIATION

Authority: Secs. 53, 63, 65, 81, 103, 104, 161, 68 Stat. 930, 933, 935, 936, 937, 948, as amended, (42 U.S.C. 2073, 2093, 2095, 2111, 2133, 2134, 2201); secs. 201, as amended, 202, 206, Pub. L. 93-438, 88 Stat. 1242, 1244, 1246, Pub. L. 94-79, 89 Stat. 413 (42 U.S.C. 5841, 5842, 5846).

For the purposes of sec. 223, 68 Stat. 958, as amended, (42 U.S.C. 2273), §§ 20.101, 20.102, 20.103(a) (b), and (f), 20.104 (a) and (b), 20.105(b), 20.106(e), 20.201, 20.202(a), 20.206, 20.207, 20.301, 20.303, 20.304 and 20.306 are issued under sec. 161b, 68 Stat 948, as amended, (42 U.S.C. 2201(b)); and §§ 20.102, 20.103(e), 20.401–20.407, 20.408(b) and 20.409 are issued under sec. 161o, 68 Stat. 950, as amended, (42 U.S.C. 2201(o)).

GENERAL PROVISIONS

§ 20.1 Purpose.

(a) The regulations in this part establish standards for protection against radiation hazards arising out of activities under licenses issued by the Nuclear Regulatory Commission and are issued pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974. [40 FR 8774]

(b) The use of radioactive material or other sources of radiation not licensed by the Commission is not subject to the regulations in this part. However, it is the purpose of the regulations in this part to control the possession, use, and transfer of licensed material by any licensee in such a manner that the total dose to an individual (including exposures to licensed and unlicensed radioactive material and to other unlicensed sources of radiation, whether in the possession of the licensee or any other person, but not including exposures to radiation from natural background sources or medical diagnosis and therapy) does not exceed the standards of radiation protection prescribed in the regulations in this part. [14 FR 13352]

(c) In accordance with recommendations of the Federal Radiation Council, approved by the President, persons engaged in activities under licenses issued by the Nuclear Regulatory Commission pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 should, in addition to complying with the requirements set forth in this part, make every reasonable effort to maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable. The term "as low as is reasonably achievable" means as low as is reasonably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest. [40 FR 58847]

§ 20.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed pursuant to the regulations in Parts 30 through 35,40,60,61,70,or72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to Part 50 of this chapter and persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter. [47 FR 57446]

§ 20.3

§ 20.3 Definitions.

(a) As used in this part:

(1) "Act" means the Atomic Energy Act of 1954 (68 Stat. 919) including any amendments thereto;

(2) "Airborne radioactive material" means any radioactive material dispersed in the air in the form of dusts, fumes, mists, vapors, or gases; [40 CFR 8774]

(3) "Byproduct material" means any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material;

(4) "Calendar quarter" means not less than 12 consecutive weeks nor more than 14 consecutive weeks. The first calendar quarter of each year shall begin in January and subsequent calendar quarters shall be such that no day is included in more than one calendar quarter or omitted from inclusion within a calendar quarter. No licensee shall change the method observed by him of determining calendar quarters except at the beginning of a calendar year. [40 FR 42567]

(5) "Commission" means the Nuclear Regulatory Commission or its duly authorized representatives;

(6) "Government agency" means any executive department, commission, independent establishment, corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States, or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the Government; [25 FR 10914]

(7) "Individual" means any human being;

(8) "Licensed material" means source material, special nuclear material, or by-product material received, possessed, used, or transferred under a general or specific license issued by the Commission pursuant to the regulations in this chapter;

(9) "License" means a license issued under the regulations in Parts 30 through 35,40,60,61,70 or 72 of this chapter. "Licensee" means the holder of such license; [47 FR 57446]

(10) "Occupational dose" includes exposure of an individual to radiation (i) in a restricted area; or (ii) in the course of employment in which the individual's duties involve exposure to radiation, provided, that "occupational dose" shall not be deemed to include any exposure of an individual to radiation for the purpose of medical diagnosis or medical therapy of such individual. [25 FR 10914]

(11) "Person" means: (i) Any individual, corporation, partnership, firm, association, trust, estate, public or private institution, group, Government agency other than the Commission or the Department (except that the Department shall be considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (ii) any legal successor, representative, agent, or agency of the foregoing. [40 FR 8774]

(12) "Radiation" means any or all of the following: alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but not sound or radio waves, or visible, infrared, or ultraviolet light; [25 FR 10914]

(13) "Radioactive material" includes any such material whether or not subject to licensing control by the Commission;

(14) "Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residental quarters, although a separate room or rooms in a residential building may be set apart as a restricted area; [25 FR 13952]

(15) "Source material" means: (i) Uranium or thorium, or any combination thereof, in any physical or chemical form; or (ii) ores which contain by weight one-twentieth of one percent (0.05%) or more of (a) uranium, (b) thorium or (c) any combination thereof. Source material does not include special nuclear material. [27 FR 5905]

(16) "Special nuclear material" means: (i) Plutonium, uranium 233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Commission, pursuant to the provisions of section 51 of the act, determines to be special nuclear material, but does not include source material; or (ii) any material artificially enriched by any of the foregoing but does not include source material; [25 FR 10914]

(17) "Unrestricted area" means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters. [25 FR 13952]

(18) "Department" means the Department of Energy established by the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565, 42 U.S.C. 7101 *et seq.*) to the extent that the Department, or its duly authorized representatives, exercises functions formerly vested in the U.S. Atomic Energy Commission, its Chairman, members, officers and components and transferred to the U.S. Energy Research and Development Administration and to the Administrator thereof pursuant to sections 104 (b), (c) and (d) of the Energy Reorganization Act of 1974 (Pub. L. 93-438, 88 Stat. 1233 at 1237, 42 U.S.C. 5814) and retransferred to the Secretary of Energy pursuant to section 301(a) of the Department of Energy Organization Act (Pub. L. 95-91, 91 Stat. 565 at 577-578, 42 U.S.C. 7151). [45 FR 24199]

(19) "Termination" means the end of employment with the licensee or, in the case of individuals not employed by the licensee, the end of a work assignment in the licensee's restricted areas in a given calendar quarter, without expectation or specific scheduling of reentry into the licensee's restricted areas during the remainder of that calendar quarter. [44 FR 32232]

(b) Definitions of certain other words and phrases as used in this part are set forth in other sections, including:

(1) "Airborne radioactivity area" defined in § 20.203;

(2) "Radiation area" and "high radiation area" defined in § 20.202;

(3) "Personnel monitoring equipment" defined in § 20.202;

(4) "Survey" defined in § 20.201;

(5) Units of measurement of dose (rad, rem) defined in § 20.4;

(6) Units of measurement of radioactivity defined in § 20.5.

§ 20.4 Units of radiation dose. [25 FR 10914]

(a) "Dose," as used in this part, is the quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body. When the regulations in this part specify a dose during a period of time, the dose means the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use. Definitions of units as used in this part are set forth in paragraphs (b) and (c) of this section.

(b) The rad, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. (One millirad (mrad)=0.001 rad.)

(c) The rem, as used in this part, is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen (r) of X-rays. (One millirem (mrem)=0.001 rem.) The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. For the purpose of the regulations in this part, any of the following is considered to be equivalent to a dose of one rem:

(1) A dose of 1 r due to X- or gamma radiation;

(2) A dose of 1 rad due to X-, gamma, or beta radiation;

(3) A dose of 0.1 rad due to neutrons or high energy protons;

(4) A dose of 0.05 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye; If it is more convenient to measure the neutron flux, or equivalent, than to determine the neutron dose in rads, as provided in paragraph (c)(3) of this section, one rem of neutron radiation may, for purposes of the regulations in this part, be assumed to be equivalent to 14 million neutrons per square centimeter incident upon the body; or, if there exists sufficient information to estimate with reasonable accuracy the approximate distribution in energy of the neutrons, the incident number of neutrons per square centimeter equivalent to one rem may be estimated from the following table:

NEUTRON FLUX DOSE EQUIVALENTS

Neutron energy (Mev)	Number of neutrons per square centimeter equivalent to a dose of 1 rem (neutrons/cm²)	Average flux to delivery 100 millirem in 40 hours (neutrons/cm² sec.)
Thermal	970 × 10⁶	670
0.0001	720 × 10⁶	500
0.005	810 × 10⁶	570
0.02	400 × 10⁶	280
0.1	120 × 10⁶	80
0.5	43 × 10⁶	30
1.0	26 × 10⁶	18
2.5	29 × 10⁶	20
5.0	26 × 10⁶	18
7.5	24 × 10⁶	17
10	24 × 10⁶	17
10 to 30	14 × 10⁶	10

(d) For determining exposures to X or gamma rays up to 3 Mev, the dose limits specified in §§ 20.101 to 20.104, inclusive, may be assumed to be equivalent to the "air dose". For the purpose of this part "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of highest dosage rate.

[39 FR 23974]

§ 20.5 Units of radioactivity.

(a) Radioactivity is commonly, and for purposes of the regulations in this part shall be, measured in terms of disintegrations per unit time or in curies.

One curie = 3.7×10^{10} disintegrations per second (dps) = 2.2×10^{12} disintegrations per minute (dpm). Commonly used submultiples of the curie are the millicurie and the microcurie:

(1) One millicurie (mCi) = 0.001 curie (Ci) = 3.7×10^{7} dps.

(2) One microcurie (μCi) = 0.000001 curie = 3.7×10^{4} dps.

(b) [Deleted 40 FR 50764.]

(c) [Deleted 39 FR 23990.]

[35 FR 15374]

§ 20.6 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding upon the Commission.

[40 FR 8774]

§ 20.7 Communications.

Except where otherwise specified in this part, all communications and reports concerning the regulations in this part should be addressed to the Executive Director for Operations, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C.; or at 7920 Norfolk Avenue, Bethesda, Maryland.

PERMISSIBLE DOSES, LEVELS, AND CONCENTRATIONS

[36 FR 1466]

§ 20.101 Radiation dose standards for individuals in restricted areas.

(a) In accordance with the provisions of § 20.102(a), and except as provided in paragraph (b) of this section, no licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from radioactive material and other sources of radiation a total occupational dose in excess of the standards specified in the following table:

REMS PER CALENDAR QUARTER

1. Whole body; head and trunk; active blood-forming organs; lens of eyes; or gonads	1¼
2. Hands and forearms; feet and ankles	18¾
3. Skin of whole body	7½

[25 FR 10914]

(b) A licensee may permit an individual in a restricted area to receive a total occupational dose to the whole body greater than that permitted under paragraph (a) of this section, provided:

[44 FR 12352]

(1) During any calendar quarter the total occupational dose to the whole body shall not exceed 3 rems; and

(2) The dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N-18) rems where "N" equals the individual's age in years at his last birthday; and

[25 FR 10914]

(3) The licensee has determined the individual's accumulated occupational dose to the whole body on Form NRC-4, or on a clear and legible record containing all the information required in that form; and has otherwise complied with the requirements of § 20.102. As used in paragraph (b), "Dose to the whole body" shall be deemed to include any dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of eye.

[44 FR 12352]

§ 20.102 Determination of prior dose.

(a) Each licensee shall require any individual, prior to first entry of the individual into the licensee's restricted area during each employment or work assignment under such circumstances that the individual will receive or is likely to receive in any period of one calendar quarter an occupational dose in excess of 25 percent of the applicable standards specified in § 20.101(a) and § 20.104(a), to disclose in a written, signed statement, either: (1) That the individual had no prior occupational dose during the current calendar quarter, or (2) the nature and amount of any occupational dose which the individual may have received during that specifically identified current calendar quarter from sources of radiation possessed or controlled by other persons. Each licensee shall maintain records of such statements until the Commission authorizes their disposition.

(b) Before permitting, pursuant to § 20.101(b), any individual in a restricted area to receive an occupational radiation dose in excess of the standards specified in § 20.101(a), each licensee shall:

[25 FR 10914]

(1) Obtain a certificate on Form NRC-4, or on a clear and legible record containing all the information required in that form, signed by the individual showing each period of time after the individual attained the age of 18 in which the individual received an occupational dose of radiation; and

(2) Calculate on Form NRC-4 in accordance with the instructions appearing therein, or on a clear and legible record containing all the information required in that form, the previously accumulated occupational dose received by the individual and the additional dose allowed for that individual under § 20.101(b).

(c)(1) In the preparation of Form NRC-4, or a clear and legible record containing all the information required in that form, the licensee shall make a reasonable effort to obtain reports of the individual's previously accumulated occupational dose. For each period for which the licensee obtains

such reports, the licensee shall use the dose shown in the report in preparing the form. In any case where a licensee is unable to obtain reports of the individual's occupational dose for a previous complete calendar quarter, it shall be assumed that the individual has received the occupational dose specified in whichever of the following columns apply:

Part of body	Column 1—Assumed exposure in rems for calendar quarters prior to Jan. 1, 1961	Column 2—Assumed exposure in rems for calendar quarters beginning on or after Jan. 1, 1961
Whole body, heads, active blood-forming organs, head and trunk, lens of eye	3¼	1¼

(2) The licensee shall retain and preserve records used in preparing Form NRC-4 until the Commission authorizes their disposition.

If calculation of the individual's accumulated occupational dose for all periods prior to January 1, 1961 yields a result higher than the applicable accumulated dose value for the individual as of that date, as specified in paragraph (b) of § 20.101, the excess may be disregarded.

§ 20.103 Exposure of individuals to concentrations of radioactive materials in air in restricted areas.

(a)(1) No licensee shall possess, use, or transfer licensed material in such a manner as to permit any individual in a restricted area to inhale a quantity of radioactive material in any period of one calendar quarter greater than the quantity which would result from inhalation for 40 hours per week for 13 weeks at uniform concentrations of radioactive material in air specified in Appendix B, Table I, Column 1.[1][2][3] If the radioactive material is of such form that intake by absorption through the skin is likely, individual exposures to radioactive material shall be controlled so that the uptake of radioactive material by any organ from either inhalation or absorption or both routes of intake[4] in any calendar quarter does not exceed that which would result from inhaling such radioactive material for 40 hours per week for 13 weeks at uniform concentrations specified in Appendix B, Table I, Column 1.

(2) No licensee shall possess, use, or transfer mixtures of U-234, U-235, and U-238 in soluble form in such a manner as to permit any individual in a restricted area to inhale a quantity of such material in excess of the intake limits specified in Appendix B, Table I, Column 1 of this part. If such soluble uranium is of a form such that absorption through the skin is likely, individual exposures to such material shall be controlled so that the uptake of such material by any organ from either inhalation or absorption or both routes of intake[4] does not exceed that which would result from inhaling such material at the limits specified in Appendix B, Table I, Column 1 and footnote 4 thereto.

(3) For purposes of determining compliance with the requirements of this section the licensee shall use suitable measurements of concentrations of radioactive materials in air for detecting and evaluating airborne radioactivity in restricted areas and in addition, as appropriate, shall use measurements of radioactivity in the body, measurements of radioactivity excreted from the body, or any combination of such measurements as may be necessary for timely detection and assessment of individual intakes of radioactivity by exposed individuals. It is assumed that an individual inhales radioactive material at the airborne concentration in which he is present unless he uses respiratory protective equipment pursuant to paragraph (c) of this section. When assessment of a particular individual's intake of radioactive material is necessary, intakes less than those which would result from inhalation for 2 hours in any one day or for 10 hours in any one week at uniform concentrations specified in Appendix B, Table I, Column 1 need not be included in such assessment, provided that for any assessment in excess of these amounts the entire amount is included.

(b)(1) The licensee shall, as a precautionary procedure, use process or other engineering controls, to the extent practicable, to limit concentrations of radioactive materials in air to levels below those which delimit an airborne radioactivity area as defined in § 20.203(d)(1)(ii).

(2) When it is impracticable to apply process or other engineering controls to limit concentrations of radioactive material in air below those defined in § 20.203(d)(1)(ii), other precautionary procedures, such as increased surveillance, limitation of working times, or provision of respiratory protective equipment, shall be used to maintain intake of radioactive material by any individual within any period of seven consecutive days as far below that intake of radioactive material which would result from inhalation of such material for 40 hours at the uniform concentrations specified in Appendix B, Table I, Column 1 as is reasonably achievable. Whenever the intake of radioactive material by any individual exceeds this 40-hour control measure, the licensee shall make such evaluations and take such actions as are necessary to assure against recurrence. The licensee shall maintain records of such occurrences, evaluations, and actions taken in a clear and readily identifiable form suitable for summary review and evaluation.

(c) When respiratory protective equipment is used to limit the inhalation of airborne radioactive material pursuant to paragraph (b)(2) of this section, the licensee shall use equipment that is certified or had certification extended by the National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA). The licensee may make allowance for this use of respiratory protective equipment in estimating exposures of individuals to this material provided that:

[1] Since the concentration specified for tritium oxide vapor assumes equal intakes by skin absorption and inhalation, the total intake permitted is twice that which would result from inhalation alone at the concentration specified for H 3 S in Appendix B, Table I, Column 1 for 40 hours per week for 13 weeks.

[2] For radon-222, the limiting quantity is that inhaled in a period of one calendar year. For radioactive materials designated "Sub" in the "Isotope" column of the table, the concentration value specified is based upon exposure to the material as an external radiation source. Individual exposures to these materials may be accounted for as part of the limitation on individual dose in § 20.101. These nuclides shall be subject to the precautionary procedures required by § 20.103(b)(1).

[3] Multiply the concentration values specified in Appendix B, Table I, Column 1, by 6.3×10^4 ml to obtain the quarterly quantity limit. Multiply the concentration value specified in Appendix B, Table I, Column 1, by 2.5×10^5 ml to obtain the annual quantity limit for Rn-222.

[4] Significant intake by ingestion or injection is presumed to occur only as a result of circumstances such as accident, inadvertence, poor procedure, or similar special conditions. Such intakes must be evaluated and accounted for by techniques and procedures as may be appropriate to the circumstances of the occurrence. Exposures so evaluated shall be included in determining whether the limitation on individual exposures in § 20.103(a)(1) has been exceeded.

[5] Regulatory guidance on assessment of individual intakes of radioactive material is given in Regulatory Guide 8.9, "Acceptable Concepts, Models, Equations and Assumptions for a Bioassay Program," single copies of which are available from the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, upon written request.

(1) The licensee selects respiratory protective equipment that provides a protection factor greater than the multiple by which peak concentrations of airborne radioactive materials in the working area are expected to exceed the values specified in Appendix B, Table I, Column 1 of this part. The equipment so selected shall be used so that the average concentration of radioactive material in the air that is inhaled during any period of uninterrupted use in an airborne radioactivity area, on any day, by any individual using the equipment, does not exceed the values specified in Appendix B, Table I, Column 1 of this part. For the purposes of this paragraph, the concentration of radioactive material in the air that is inhaled when respirators are worn may be estimated by dividing the ambient concentration in air by the protection factor specified in Appendix A of this part. If the exposure is later found to be greater than estimated, the corrected value shall be used; if the exposure is later found to be less than estimated, the corrected value may be used.

(2) The licensee maintains and implements a respiratory protection program that includes, as a minimum: air sampling sufficient to identify the hazard, permit proper equipment selection and estimate exposures; surveys and bioassays as appropriate to evaluate actual exposures; written procedures regarding selection, fitting, and maintenance of respirators, and testing of respirators for operability immediately prior to each use; written procedures regarding supervision and training of personnel and issuance records; and determination by a physician prior to initial use of respirators, and at least every 12 months thereafter, that the individual user is physically able to use the respiratory protective equipment.

(3) A written policy statement on respirator usage shall be issued covering such things as: use of practicable engineering controls instead of respirators; routine, nonroutine, and emergency use of respirators; and periods of respirator use and relief from respirator use. The licensee shall advise each respirator user that the user may leave the area at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that might require such relief.

(4) The licensee uses equipment within limitations for type and mode of use and provides proper visual, communication, and other special capabilities (such as adequate skin protection) when needed.

(d) Unless otherwise authorized by the Commission, the licensee shall not assign protection factors in excess of those specified in Appendix A of this part in selecting and using respiratory protective equipment. The Commission may authorize a licensee to use higher protection factors on receipt of an application (1) describing the situation for which a need exists for higher protection factors, and (2) demonstrating that the respiratory protective equipment will provide these higher protection factors under the proposed conditions of use.

(e) Where equipment of a particular type has not been tested and certified, or had certification extended, by NIOSH/MSHA, or where there is no existing schedule for test and certification of certain equipment, the licensee shall not make allowance for this equipment without specific authorization by the Commission. An application for this authorization must include a demonstration by testing, or on the basis of reliable test information, that the material and performance characteristics of the equipment are capable of providing the proposed degree of protection under anticipated conditions of use.

(f) Only equipment that has been specifically certified or had certification extended for emergency use by NIOSH/MSHA shall be used as emergency devices.

(g) The licensee shall notify, in writing, the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix D at least 30 days before the date that respiratory protective equipment is first used under the provisions of this section.

47 FR 16162

47 FR 16162

§ 20.104 Exposure of minors.

(a) No licensee shall possess, use, or transfer licensed material in such a manner as to cause any individual within a restricted area who is under 18 years of age, to receive in any period of one calendar quarter from radioactive material and other sources of radiation in the licensee's possession a dose in excess of 10 percent of the limits specified in the table in paragraph (a) of § 20.101.

(b) No licensee shall possess, use or transfer licensed material in such a manner as to cause any individual within a restricted area, who is under 18 years of age to be exposed to airborne radioactive material possessed by the licensee in an average concentration in excess of the limits specified in Appendix B, Table II of this part. For purposes of this paragraph, concentrations may be averaged over periods not greater than a week.

45 FR 10914

(c) The provisions of §§ 20.103(b)(2) and 20.103(c) shall apply to exposures subject to paragraph (b) of this section except that the references in §§ 20.103(b)(2) and 20.103(c) to Appendix B, Table I, Column 1 shall be deemed to be references to Appendix B, Table II, Column 1.

41 FR 52302

§ 20.105 Permissible levels of radiation in unrestricted areas.

(a) There may be included in any application for a license or for amendment of a license proposed limits upon levels of radiation in unrestricted areas resulting from the applicant's possession or use of radioactive material and other sources of radiation. Such applications should include information as to anticipated average radiation levels and anticipated occupancy times for each unrestricted area involved. The Commission will approve the proposed limits if the applicant demonstrates that the proposed limits are not likely to cause any individual to receive a dose to the whole body in any period of one calendar year in excess of 0.5 rem.

(b) Except as authorized by the Commission pursuant to paragraph (a) of this section, no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days.

25 FR 10914

(c) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," shall comply with that part.

46 FR 18525

§ 20.106 Radioactivity in effluents to unrestricted areas.

(a) A licensee shall not possess, use, or transfer licensed material so as to release to an unrestricted area radioactive material in concentrations which exceed the limits specified in Appendix B, Table II of this part, except as authorized pursuant to § 20.302 or paragraph (b) of this section. For purposes of this section concentrations may be averaged over a period not greater than one year.

29 FR 14434

(b) An application for a license or amendment may include proposed limits higher than those specified in paragraph (a) of this section. The Commission will approve the proposed limits if the applicant demonstrates:

(1) That the applicant has made a reasonable effort to minimize the radioactivity contained in effluents to unrestricted areas; and

(2) That it is not likely that radioactive material discharged in the effluent would result in the exposure of an individual to concentrations of radioactive material in air or water exceeding the limits specified in Appendix B, Table II of this part.

(c) An application for higher limits pursuant to paragraph (b) of this section shall include information demonstrating that the applicant has made a reasonable effort to minimize the radioactivity discharged in effluents to unrestricted areas, and shall include, as pertinent:

(1) Information as to flow rates, total volume of effluent, peak concentration of each radionuclide in the effluent, and concentration of each radionuclide in the effluent averaged over a period of one year at the point where the effluent leaves a stack, tube, pipe, or similar conduit;

(2) A description of the properties of the effluents, including:

(i) Chemical composition;

(ii) Physical characteristics, including suspended solids content in liquid effluents, and nature of gas or aerosol for air effluents;

(iii) The hydrogen ion concentrations (p^H) of liquid effluents; and

(iv) The size range of particulates in effluents released into air.

(3) A description of the anticipated human occupancy in the unrestricted area where the highest concentration of radioactive material from the effluent is expected, and, in the case of a river or stream, a description of water uses downstream from the point of release of the effluent.

(4) Information as to the highest concentration of each radionuclide in an unrestricted area, including anticipated concentrations averaged over a period of one year:

(i) In air at any point of human occupancy; or

(ii) In water at points of use downstream from the point of release of the effluent.

(5) The background concentration of radionuclides in the receiving river or stream prior to the release of liquid effluent.

(6) A description of the environmental monitoring equipment, including sensitivity of the system, and procedures and calculations to determine concentrations of radionuclides in the unrestricted area and possible reconcentrations of radionuclides.

(7) A description of the waste treatment facilities and procedures used to reduce the concentration of radionuclides in effluents prior to their release.

(d) For the purposes of this section the concentration limits in Appendix B, Table II of this part shall apply at the boundary of the restricted area. The concentration of radioactive material discharged through a stack, pipe or similar conduit may be determined with respect to the point where the material leaves the conduit. If the conduit discharges within the restricted area, the concentration at the boundary may be determined by applying appropriate factors for dilution, dispersion, or decay between the point of discharge and the boundary.

(e) In addition to limiting concentrations in effluent streams, the Commission may limit quantities of radioactive materials released in air or water during a specified period of time if it appears that the daily intake of radioactive material from air, water, or food by a suitable sample of an exposed population group, averaged over a period not exceeding one year, would otherwise exceed the daily intake resulting from continuous exposure to air or water containing one-third the concentration of radioactive materials specified in Appendix B, Table II of this part.

(f) The provisions of paragraphs (a) through (e) of this section do not apply to disposal of radioactive material into sanitary sewerage systems, which is governed by § 20.303.

(g) In addition to other requirements of this part, licensees engaged in uranium fuel cycle operations subject to the provisions of 40 CFR Part 190, "Environmental Radiation Protection Standard for Nuclear Power Operations," shall comply with that part.

§ 20.107 Medical diagnosis and therapy.

Nothing in the regulations in this part shall be interpreted as limiting the intentional exposure of patients to radiation for the purpose of medical diagnosis or medical therapy.

§ 20.108 Orders requiring furnishing of bio-assay services.

Where necessary or desirable in order to aid in determining the extent of an individual's exposure to concentrations of radioactive material, the Commission may incorporate appropriate provisions in any license, directing the licensee to make available to the individual appropriate bio-assay services and to furnish a copy of the reports of such services to the Commission.

Precautionary Procedures

§ 20.201 Surveys.

(a) As used in the regulations in this part, "survey" means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and measurements of levels of radiation or concentrations of radioactive material present.

(b) Each licensee shall make or cause to be made such surveys as (1) may be necessary for the licensee to comply with the regulations in this part, and (2) are reasonable under the circumstances to evaluate the extent of radiation hazards that may be present.

§ 20.202 Personnel monitoring.

(a) Each licensee shall supply appropriate personnel monitoring equipment to, and shall require the use of such equipment by:

(1) Each individual who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in paragraph (a) of § 20.101.

(2) Each individual under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in paragraph (a) of § 20.101.

(3) Each individual who enters a high radiation area.

(b) As used in this part,

(1) "Personnel monitoring equipment" means devices designed to be worn or carried by an individual for the purpose of measuring the dose received (e.g., film badges, pocket chambers, pocket dosimeters, film rings, etc.);

(2) "Radiation area" means any area, accessible to personnel, in which there exists radiation, originating in whole or in part within licensed material, at such levels that a major portion of the body could receive in any one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirems;

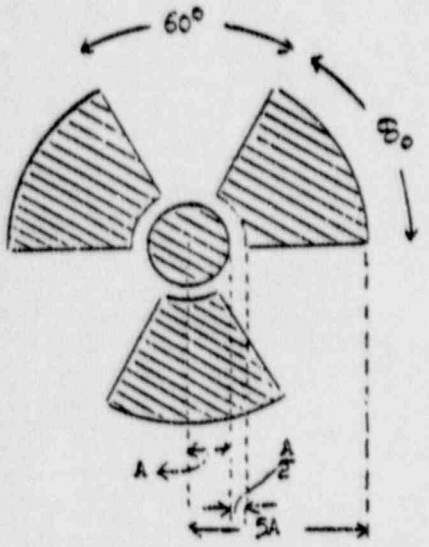
(3) "High radiation area" means any area, accessible to personnel, in which there exists radiation originating in whole or in part within licensed material at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirem.

§ 20.203 Caution signs, labels, signals and controls.

(a) *General.* (1) Except as otherwise authorized by the Commission, symbols prescribed by this section shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed by this section is the conventional three-bladed design:

RADIATION SYMBOL

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.



35 FR 5033

(2) In addition to the contents of signs and labels prescribed in this section, licensees may provide on or near such signs and labels any additional information which may be appropriate in aiding individuals to minimize exposure to radiation or to radioactive material.

(b) *Radiation areas.* Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

RADIATION AREA

(c) *High radiation areas.* (1) Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

HIGH RADIATION AREA

[1] Or "Danger"

(2) Each entrance or access point to a high radiation area shall be:

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

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

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

35 FR 5033

(3) The controls required by paragraph (c)(2) of this section shall be established in such a way that no individual will be prevented from leaving a high radiation area.

(4) In the case of a high radiation area established for a period of 30 days or less, direct surveillance to prevent unauthorized entry may be substituted for the controls required by paragraph (c)(2) of this section.

(5) Any licensee, or applicant for a license, may apply to the Commission for approval of methods not included in paragraphs (c)(2) and (4) of this section for controlling access to high radiation areas. The Commission will approve the proposed alternatives if the licensee or applicant demonstrates that the alternative methods of control will prevent unauthorized entry into a high radiation area, and that the requirement of paragraph (c)(3) of this section is met.

42 FR 64619

(6) Each area in which there may exist radiation levels in excess of 500 rems in one hour at one meter from a sealed radio-active source [2] that is used to irradiate materials shall: [3]

43 FR 2167

(i) Have each entrance or access point equipped with entry control devices which shall function automatically to prevent any individual from inadvertently entering the area when such radiation levels exist; permit deliberate entry into the area only after a control device is actuated that shall cause the radiation level within the area, from the sealed source, to be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and prevent operation of the source if the source would produce radiation levels in the area that could result in a dose to an individual in excess of 100 mrem in one hour. The entry control devices required by this paragraph (c)(6) shall be established in such a way that no individual will be prevented from leaving the area.

42 FR 64619

(ii) Be equipped with additional control devices such that upon failure of the entry control devices to function as required by paragraph (c)(6)(i) of this section the radiation level within the area, from the sealed source, shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make an individual attempting to enter the area aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of such failure of the entry control devices.

(iii) Be equipped with control devices such that upon failure or removal of physical radiation barriers other than the source's shielded storage container the radiation level from the source shall be reduced below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour; and visible and audible alarm signals shall be generated to make potentially affected individuals aware of the hazard and the licensee or at least one other individual, who is familiar with the activity and prepared to render or summon assistance, aware of the failure or removal of the physical barrier. When the shield for the stored source is a liquid, means shall be provided to monitor the integrity of the shield and to signal, automatically, loss of adequate shielding. Physical radiation barriers that com-

[2] This paragraph (c)(6) does not apply to radioactive sources that are used in teletherapy, in radiography, or in completely self-shielded irradiators in which the source is both stored and operated within the same shielding radiation barrier and, in the designed configuration of the irradiator, is always physically inaccessible to any individual and cannot create high levels of radiation in an area that is accessible to any individual. This paragraph (c)(6) also does not apply to sources from which the radiation is incidental to some other use nor to nuclear reactor generated radiation other than radiation from byproduct, source, or special nuclear materials that are used in sealed sources in non-self-shielded irradiators.

[3] These requirements apply after Mar. 14, 1978. Each person licensed to conduct activities to which this paragraph (c)(6) applies and who is not in compliance with the provisions of this paragraph on Mar. 14, 1978, shall file with the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, on or before June 14, 1978, information describing in detail the actions taken or to be taken to achieve compliance with this paragraph by Dec. 14, 1978, and may continue activities in conformance with present license conditions and the provisions of the previously effective § 20.2034 until such compliance is achieved. For such persons compliance must be achieved not later than Dec. 14, 1978.

prise permenent structural components, such as walls, that have no credible probability of failure or removal in ordinary circumstances need not meet the requirements of this paragraph (c)(5)(iii). [42 FR 54619]

(iv) Be equipped with devices that will automatically generate visible and audible alarm signals to alert personnel in the area before the source can be put into operation and in sufficient time for any individual in the area to operate a clearly identified control device which shall be installed in the area and which can prevent the source from being put into operation.

(v) Be controlled by use of such administrative procedure and such devices as are necessary to assure that the area is cleared of personnel prior to each use of the source preceding which use it might have been possible for an individual to have entered the area. [43 FR 2167]

(vi) Be checked by a physical radiation measurement to assure that prior to the first individual's entry into the area after any use of the source, the radiation level from the source in the area is below that at which it would be possible for an individual to receive a dose in excess of 100 mrem in one hour.

(vii) Have entry control devices required in paragraph (c)(6)(i) of this section which have been tested for proper functioning prior to initial operation with such source of radiation on any day that operations are not uninterruptedly continued from the previous day or before resuming operations after any unintended interruption, and for which records are kept of the dates, times, and results of such tests of function. No operations other than those necessary to place the source in safe condition or to effect reparis on controls shall be conducted with such source unless control devices are functioning properly. The licensee shall submit an acceptable schedule for more complete periodic tests of the entry control and warning systems to be established and adhered to as a condition of the license. [42 FR 54619]

(viii) Have those entry and exit portals that are used in transporting materials to and from the irradiation area, and that are not intended for use by individuals, controlled by such devices and administrative procedures as are necessary to physically protect and warn against inadvertent entry by any individual through such portals. Exit portals for processed materials shall be equipped to detect and signal the presence of loose radiation sources that are carried toward such an exit and to automatically prevent such loose sources from being carried out of the area.

(7) Licensees with, or applicants for, licenses for radiation sources that are within the purview of paragraph (c)(6) of this section, and that must be used in a variety of positions or in peculiar locations, such as open fields or forests, that make it impracticable to comply with certain requirements of paragraph (c)(6) of this section, such as those for the automatic control of radiation levels, may apply to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, for approval, prior to use of safety measures that are alternative to those specified in paragraph (c)(6) of this section, and that will provide at least an equivalent degree of personnel protection in the use of such sources. At least one of the alternative measures must include an entry-preventing interlock control based on a physical measurement of radiation that assures the absence of high radiation levels before an individual can gain access to an area where such sources are used. [43 FR 2167]

(d) *Airborne radioactivity areas.* (1) As used in the regulations in this part "airborne radioactivity area" means (i) any room, enclosure, or operating area in which airborne radioactive materials composed wholly or partly of licensed material, exist in concentrations in excess of the amounts specified in Appendix B, Table I, Column 1 of this part; or (ii) any room, enclosure, or operating area in which airborne radioactive material composed wholly or partly of licensed material exists in concentrations which, averaged over the number of hours in any week during which individuals are in the area, exceed 25 percent of the amounts specified in Appendix B Table I, Column 1 of this part. [25 FR 10914]

(2) Each airborne radioactivity area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

CAUTION [1]

AIRBORNE RADIOACTIVITY AREA

(e) *Additional requirements.* (1) Each area or room in which licensed material is used or stored and which contains any radioactive material (other than natural uranium or thorium) in an amount exceeding 10 times the quantity of such material specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words:

[1] Or "Danger".

[2] As appropriate, the information will include radiation levels, kinds of material, estimate of activity, date for which activity is estimated, mass enrichment, etc.

CAUTION [1]

RADIOACTIVE MATERIAL(S)

(2) Each area or room in which natural uranium or thorium is used or stored in any amount exceeding one hundred times the quantity specified in Appendix C of this part shall be conspicuously posted with a sign or signs bearing the radiation caution symbol and the words: [25 FR 10914]

CAUTION [1]

RADIOACTIVE MATERIAL(S)

(f) *Containers.* (1) Except as provided in paragraph (f)(3) of this section, each container of licensed material shall bear a durable, clearly visible label identifying the radioactive contents.

(2) A label required pursuant to paragraph (f)(1) of this section shall bear the radiation caution symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL". It shall also provide sufficient information [2] to permit individuals handling or using the containers, or working in the vicinity thereof, to take precautions to avoid or minimize exposures.

(3) Notwithstanding the provisions of paragraph (f)(1) of this section labeling is not required: [31 FR 10514]

(i) For containers that do not contain licensed materials in quantities greater than the applicable quantities listed in Appendix C of this part.

(ii) For containers containing only natural uranium or thorium in quantities no greater than 10 times the applicable quantities listed in Appendix C of this part.

(iii) For containers that do not contain licensed materials in concentrations greater than the applicable concentrations listed in Appendix B, Table I, Column 2, of this part.

(iv) For containers when they are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established by the regulations in this part.

(v) For containers when they are in transport and packaged and labeled in accordance with regulations of the Department of Transportation. [31 FR 10514, 31 FR 19546]

(vi) For containers which are accessible [2] only to individuals authorized to handle or use them, or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

(vii) For manufacturing or process equipment, such as nuclear reactors, reactor components, piping, and tanks.

(4) Each licensee shall, prior to disposal of an empty uncontaminated container to unrestricted areas, remove or deface the radioactive material label or otherwise clearly indicate that the container no longer contains radioactive materials. [43 FR 22171]

§ 20.204 Same: exceptions. [25 FR 10884]

Notwithstanding the provisions of § 20.203,

(a) A room or area is not required to be posted with a caution sign because of the presence of a sealed source provided the radiation level twelve inches from the surface of the source container or housing does not exceed five millirem per hour.

(b) Rooms or other areas in hospitals are not required to be posted with caution signs, and control of entrance or access thereto pursuant to § 20.203(c) is not required, because of the presence of patients containing byproduct material provided that there are personnel in attendance who will take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the regulations in this part. [35 FR 5033]

(c) Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours provided that (1) the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the regulations in this part and; (2) such area or room is subject to the licensee's control. [25 FR 10884]

(d) A room or other area is not required to be posted with a caution sign, and control is not required for each entrance or access point to a room or other area which is a high radiation area solely because of the presence of radioactive materials prepared for transport and packaged and labeled in accordance with regulations of the Department of Transportation. [35 FR 5033]

§ 20.205 Procedures for picking up, receiving, and opening packages. [39 FR 17972]

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and [41 FR 16445]

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries. [39 FR 17972]

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify[1] the final delivering carrier and, by telephone and telegraph, mailgram or facsimile, the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D of this part. [41 FR 16445]

[1] For example, containers in locations such as water-filled canals, storage vaults, or hot cells.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

[1] The definitions of "transport group" and "special form" are specified in § 71.4 of this chapter.

[1] The reporting requirements in § 20.205 have been approved by GAO under number B-180 225 (R 0054).

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours. [39 FR 17972]

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour,

the licensee shall immediately notify by telephone and telegraph mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier. [41 FR 16445]

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened. [39 FR 17972]

§ 20.206 Instruction of personnel. [50 FR 22220]

Instructions required for individuals working in or frequenting any portion of a restricted area are specified in § 19.12 of this chapter.

§ 20.207 Storage and control of licensed materials in unrestricted areas. [40 FR 26619]

(a) Licensed materials stored in an unrestricted area shall be secured from unauthorized removal from the place of storage.

(b) Licensed materials in an unrestricted area and not in storage shall be

tended under the constant surveillance and immediate control of the licensee.

Waste Disposal

§ 20.301 General requirement.

No licensee shall dispose of licensed material except:

(a) By transfer to an authorized recipient as provided in the regulations in Parts 30, 40, 60, 61, 70 or 72 of this chapter, whichever may be applicable; or

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(b) As authorized under § 20.302 or Part 61 of this chapter; or

46 FR 16230

(c) As provided in § 20.303, applicable to the disposal of licensed material by release into sanitary sewerage systems, or in § 20.306 for disposal of specific wastes, or in § 20.106 (Radioactivity in effluents to unrestricted areas).

§ 20.302 Method for obtaining approval of proposed disposal procedures.

(a) Any licensee or applicant for a license may apply to the Commission for approval of proposed procedures to dispose of licensed material in a manner not otherwise authorized in the regulations in this chapter. Each application should include a description of the licensed material and any other radioactive material involved, including the quantities and kinds of such material and the levels of radioactivity involved, and the proposed manner and conditions of disposal. The application should also include an analysis and evaluation of pertinent information as to the nature of the environment, including topographical, geological, meteorological, and hydrological characteristics; usage of ground and surface waters in the general area; the nature and location of other potentially affected facilities; and procedures to be observed to minimize the risk of unexpected or hazardous exposures.

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(b) The Commission will not approve any application for a license for disposal of licensed material at sea unless the applicant shows that sea disposal offers less harm to man or the environment than other practical alternative methods of disposal.

§ 20.303 Disposal by release into sanitary sewerage systems.

No licensee shall discharge licensed material into a sanitary sewerage system unless:

(a) It is readily soluble or dispersible in water; and

(b) The quantity of any licensed or other radioactive material released into the system by the licensee in any one day does not exceed the larger of paragraphs (b)(1) or (2) of this section.

(1) The quantity which, if diluted by the average daily quantity of sewage released into the sewer by the licensee, will result in an average concentration equal to the limits specified in Appendix B, Table I, Column 2 of this part; or

(2) Ten times the quantity of such material specified in Appendix C of this part; and

(c) The quantity of any licensed or other radioactive material released in any one month, if diluted by the average monthly quantity of water released by the licensee, will not result in an average concentration exceeding the limits specified in Appendix B, Table I, Column 2 of this part; and

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(d) The gross quantity of licensed and other radioactive material, excluding hydrogen-3 and carbon-14, released into the sewerage system by the licensee does not exceed one curie per year. The quantities of hydrogen-3 and carbon-14 released into the sanitary sewerage system may not exceed 5 curies per year for hydrogen-3 and 1 curie per year for carbon-14. Excreta from individuals undergoing medical diagnosis or therapy with radioactive material shall be exempt from any limitations contained in this section.

§ 20.305 Treatment or disposal by incineration.

No licensee shall treat or dispose of licensed material by incineration, except for materials listed under § 20.306 or as specifically approved by the Commission pursuant to §§ 20.106(b) and 20.302.

§ 20.306 Disposal of specific wastes.

Any licensee may dispose of the following licensed material without regard to its radioactivity:

(a) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of medium, used for liquid scintillation counting; and

(b) 0.05 microcuries or less of hydrogen-3 or carbon-14, per gram of animal tissue averaged over the weight of the entire animal; provided however, tissue may not be disposed of under this section in a manner that would permit its use either as food for humans or as animal feed.

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(c) Nothing in this section, however, relieves the licensee of maintaining records showing the receipt, transfer and disposal of such byproduct material as specified in § 30.51 of this chapter; and

(d) Nothing in this section relieves the licensee from complying with other applicable Federal, State and local regulations governing any other toxic or hazardous property of these materials.

§ 20.311 Transfer for disposal and manifests.

(a) Purpose. The requirements of this section are designed to control transfers of radioactive waste intended for disposal at a land disposal facility and establish a manifest tracking system and supplement existing requirements concerning transfers and recordkeeping for such wastes. The reporting and recordkeeping requirements contained in this section have been approved by the Office of Management and Budget; OMB approval No. 3150–0014.

(b) Each shipment of radioactive waste to a licensed land disposal facility must be accompanied by a shipment manifest that contains the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste; the volume; radionuclide identity and quantity; the total radioactivity; and the principal chemical form. The solidification agent must be specified. Waste containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in § 61.55 of this chapter must be clearly identified as such in the manifest. The total quantity of the radionuclides H–3, C–14, Tc–99 and I–129 must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or

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Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

(c) Each manifest must include a certification by the waste generator that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

(d) Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in paragraphs (d)(1) through (8) of this section. Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of paragraphs (d)(6) through (8) of this section. A licensee shall:

(1) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(2) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with § 61.55 of this chapter;

(3) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

(4) Prepare shipping manifests to meet the requirements of §§ 20.311 (b) and (c) of this part;

(5) Forward a copy of the manifest to the intended recipient, at the time of shipment; or, deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

(6) Include one copy of the manifest with the shipment;

(7) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter; and,

(8) For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(e) Any waste collector licensee who handles only prepackaged waste shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in paragraph (b) of this section. The collector licensee shall certify that nothing has been done to the waste which would invalidate the generator's certification;

(3) Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

(4) Include the new manifest with the shipment to the disposal site;

(5) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter, and retain information from generator manifests until disposition is authorized by the Commission; and,

(6) For any shipments or any part of a shipment for which acknowledgement of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(f) Any licensed waste processor who treats or repackages wastes shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest that meets the requirements of paragraphs (b) and (c) of this section. Preparation of the new manifest reflects that the processor is responsible for the waste;

(3) Prepare all wastes so that the waste is classified according to § 61.55 and meets the waste characteristics requirements in § 61.56 of this chapter;

(4) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§ 61.55 and 61.57 of this chapter;

(5) Conduct a quality control program to assure compliance with §§ 61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

(6) Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector;

(7) Include the new manifest with the shipment;

(8) Retain copies of original manifests and new manifests and documentation of acknowledgement of receipt as the record of transfer of licensed material required by Parts 30, 40, and 70 of this chapter; and

(9) For any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(g) The land disposal facility operator shall:

(1) Acknowledge receipt of the waste within one week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received;

(2) Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition; and

(3) Notify the shipper (i.e., the generator, the collector, or processor) and the Director of the nearest Commission Regional Office listed in Appendix D of this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

(h) Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, must:

(1) Be investigated by the shipper if the shipper has not received notification of receipt within 20 days after transfer; and

(2) Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in Appendix D of this part. Each licensee who conducts a trace investigation shall file a written report with the nearest Commission's Regional office within 2 weeks of completion of the investigation.

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§ 20.401 Records of surveys, radiation monitoring, and disposal.

(a) Each licensee shall maintain records showing the radiation exposures of all individuals for whom personnel monitoring is required under § 20.202 of the regulations in this part. Such records shall be kept on Form NRC-5, in accordance with the instructions contained in that form or on clear and legible records containing all the information required by Form NRC-5. The doses entered on the forms or records shall be for periods of time not exceeding one calendar quarter.

[28 FR 6084]

(b) Each licensee shall maintain records in the same units used in this part, showing the results of surveys required by § 20.201(b), monitoring required by §§ 20.205(b) and 20.205(c), and disposals made under §§ 20.302, 20.303, removed § 20.304,[1] and Part 61 of this chapter.

[47 FR 57446]

(c)(1) Records of individual exposure to radiation and to radioactive material which must be maintained pursuant to the provisions of paragraph (a) of this section and records of bioassays, including results of whole body counting examinations, made pursuant to § 20.108, shall be preserved until the Commission authorizes disposition.

(2) Records of the results of surveys and monitoring which must be maintained pursuant to paragraph (b) of this section shall be preserved for two years after completion of the survey except that the following records shall be maintained until the Commission authorizes their disposition: (i) Records of the results of surveys to determine compliance with § 20.103(a); (ii) in the absence of personnel monitoring data, records of the results of surveys to determine external radiation dose; and (iii) records of the results of surveys used to evaluate the release of radioactive effluents to the environment.

[41 FR 16300]

(3) Records of disposal of licensed materials made pursuant to §§ 20.302, 20.303, removed § 20.304,[1] and Part 61 of this chapter are to be maintained until the Commission authorizes their disposition.

(4) Records which must be maintained pursuant to this part may be the original or a reproduced copy or microform if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations.

(5) If there is a conflict between the Commission's regulations in this part, license condition, or technical specification, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the retention period specified in the regulations in this part for such records shall apply unless the Commission pursuant to § 20.501, has granted a specific exemption from the record retention requirements specified in the regulations in this part.

§ 20.402 Reports of theft or loss of licensed material.

(a)(1) Each licensee shall report to the Commission, by telephone, immediately after it determines that a loss or theft of licensed material has occurred in such quantities and under such circumstances that it appears to the licensee that a substantial hazard may result to persons in unrestricted areas.

(2) Reports must be made as follows:

(i) Licensees having an installed Emergency Notification System shall make the reports to the NRC Operations Center in accordance with § 50.72 of this chapter.

(ii) All other licensees shall make reports to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

(b) Each licensee who makes a report under paragraph (a) of this section shall, within 30 days after learning of the loss or theft, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part. The report shall include the following information:

(1) A description of the licensed material involved, including kind, quantity, chemical, and physical form;

(2) A description of the circumstances under which the loss or theft occurred;

(3) A statement of disposition or probable disposition of the licensed material involved;

(4) Radiation exposures to individuals, circumstances under which the exposures occurred, and the extent of possible hazard to persons in unrestricted areas;

(5) Actions which have been taken, or will be taken, to recover the material; and

(6) Procedures or measures which have been or will be adopted to prevent a recurrence of the loss or theft of licensed material.

(c) Subsequent to filing the written report the licensee shall also report any substantive additional information on the loss or theft which becomes available to the licensee, within 30 days after he learns of such information.

(d) Any report filed with the Commission pursuant to this section shall be so prepared that names of individuals who may have received exposure to radiation are stated in a separate part of the report.

(e) For holders of an operating license for a nuclear power plant, the events included in paragraph (b) of this section must be reported in accordance with the procedures described in § 50.73 (b), (c), (d), (e), and (g) of this chapter and must include the information required in paragraph (b) of this section. Events reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraph (b) of this section.

§ 20.403 Notifications of incidents.

(a) *Immediate notification.* Each licensee shall immediately report any events involving byproduct, source, or special nuclear material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual of 150 rems or more or radiation; or exposure of the feet, ankles, hands or forearms of any individual to 375 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 5,000 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one working week or more of the operation of any facilities affected; or

(4) Damage to property in excess of $200,000.

(b) *Twenty-four hour notification.* Each licensee shall within 24 hours of discovery of the event, report any event involving licensed material possessed by the licensee that may have caused or threatens to cause:

(1) Exposure of the whole body of any individual to 5 rems or more of radiation; exposure of the skin of the whole body of any individual to 30 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation; or

(2) The release of radioactive material in concentrations which, if averaged over a period of 24 hours, would exceed 500 times the limits specified for such materials in Appendix B, Table II of this part; or

(3) A loss of one day or more of the operation of any facilities affected; or

(4) Damage to property in excess of $2,000.

(c) Any report filed with the Commission pursuant to this section shall be prepared so that names of individuals who have received exposure to radiation will be stated in a separate part of the report.

(d) Reports made by licensees in response to the requirements of this section must be made as follows:

(1) Licensees that have an installed Emergency Notification System shall make the reports required by paragraphs (a) and (b) of this section to the NRC Operations Center in accordance with § 50.72 of this chapter.

(2) All other licensees shall make the reports required by paragraphs (a) and (b) of this section by telephone and by telegram, mailgram, or facsimile to the Administrator of the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.404 [Reserved]

§ 20.405 Reports of overexposures and excessive levels and concentrations.

(a)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing concerning any one of the following types of incidents within 30 days of its occurrence:

(i) Each exposure of an individual to radiation in excess of the applicable limits in §§ 20.101 or 20.104(a) of this part, or the license;

(ii) Each exposure of an individual to radioactive material in excess of the applicable limits in §§ 20.103(a)(1), 20.103(a)(2), or 20.104(b) of this part, or in the license;

(iii) Levels of radiation or concentrations of radioactive material in a restricted area in excess of any other applicable limit in the license;

(iv) Any incident for which notification is required by § 20.403 of this part; or

(v) Levels of radiation or concentrations of radioactive material (whether or not involving excessive exposure of any individual) in an unrestricted area in excess of ten times any applicable limit set forth in this part or in the license.

(2) Each report required under paragraph (a)(1) of this section must describe the extent of exposure of individuals to radiation or to radioactive material, including:

(i) Estimates of each individual's exposure as required by paragraph (b) of this section;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels or concentrations; and

(iv) Corrective steps taken or planned to prevent a recurrence.

(b) Any report filed with the Commission pursuant to paragraph (a) of this section shall include for each individual exposed the name, social security number, and date of birth, and an estimate of the individual's exposure. The report shall be prepared so that this information is stated in a separate part of the report.

(c)(1) In addition to any notification required by § 20.403 of this part, each licensee shall make a report in writing of levels of radiation or releases of radioactive material in excess of limits specified by 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," or in excess of license conditions related to compliance with 40 CFR Part 190.

(2) Each report submitted under paragraph (c)(1) of this section must describe:

(i) The extent of exposure of individuals to radiation or to radioactive material;

(ii) Levels of radiation and concentrations of radioactive material involved;

(iii) The cause of the exposure, levels, or concentrations; and

(iv) Corrective steps taken or planned to assure against a recurrence, including the schedule for achieving conformance with 40 CFR Part 190 and with associated license conditions.

(d) For holders of an operating license for a nuclear power plant, the incidents included in paragraphs (a) or (c) of this section must be reported in accordance with the procedures described in paragraphs 50.73 (b), (c), (d), (e), and (g) of this chapter and must also include the information required by paragraphs (a) and (c) of this section. Incidents reported in accordance with § 50.73 of this chapter need not be reported by a duplicate report under paragraphs (a) or (c) of this section.

(e) All other licensees who make reports under paragraphs (a) or (c) of this section shall, within 30 days after learning of the overexposure or excessive level or concentration, make a report in writing to the U.S. Nuclear Regulatory Commission, Document Control Desk, Washington, D.C. 20555, with a copy to the appropriate NRC Regional Office listed in Appendix D of this part.

§ 20.406 [Reserved]

§ 20.407 Personnel monitoring reports.

Each person described in § 20.408 of this part shall, within the first quarter of each calendar year, submit to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the reports specified in paragraphs (a) and (b) of this section covering the preceding calendar year.[1] All other persons specifically licensed by the Commission shall, within the first quarter of calendar years 1979 and 1980, submit to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, the reports specified in paragraphs (a) and (b) of this section covering the preceding calendar years 1978 and 1979.

(a) A report of either (1) the total number of individuals for whom personnel monitoring was required under § 20.202(a) or § 34.33(a) of this chapter during the calendar year; or (2) the total number of individuals for whom personnel monitoring was provided during the calendar year: *Provided, however,* That such total includes at least the number of individuals required to be reported under paragraph (a)(1) of this section. The report shall indicate whether it is submitted in accordance with paragraph (a)(1) or (a)(2) of this section. If personnel monitoring was not required to be provided to any individual by the licensee under §§ 20.202(a) or 34.33(a) of this chapter during the calendar year, the licensee shall submit a negative report indicating that such personnel monitoring was not required.

(b) A statistical summary report of the personnel monitoring information recorded by the licensee for individuals for whom personnel monitoring was either required or provided, as described in paragraph (a) of this section, indicating the number of individuals whose total whole body exposure recorded during the previous calendar year was in each of the following estimated exposure ranges:

Estimated whole body exposure range (rems)[1]	Number of individuals in each range
No measurable exposure	
Measurable exposure less than 0.1	
0.1 to 0.25	
0.25 to 0.5	
0.5 to 0.75	
0.75 to 1	
1 to 2	
2 to 3	
3 to 4	
4 to 5	
5 to 6	
6 to 7	
7 to 8	
8 to 9	
9 to 10	
10 to 11	
11 to 12	
12+	

[1]Individual values exactly equal to the values separating exposure ranges shall be reported in the higher range.

The low exposure range data are required in order to obtain better information about the exposures actually recorded. This section does not require improved measurements.

§ 20.408 Reports of personnel monitoring on termination of employment or work.

(a) This section applies to each person licensed by the Commission to:

(1) Operate a nuclear reactor designed to produce electrical or heat energy pursuant to § 50.21(b) or § 50.22 of this chapter or a testing facility as defined in § 50.2(r) of this chapter;

(2) Possess or use byproduct material for purposes of radiography pursuant to Parts 30 and 34 of this chapter;

(3) Possess or use at any one time, for purposes of fuel processing, fabricating, or reprocessing, special nuclear material in a quantity exceeding 5,000 grams of contained uranium-235, uranium-233, or plutonium or any combination thereof pursuant to Part 70 of this chapter;

(4) Possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter; or

(5) Possess spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to Part 72 of this chapter; or

(6) Possess or use at any one time, for processing or manufacturing for distribution pursuant to Parts 30, 32, or 33 of this Chapter, byproduct material in quantities exceeding any one of the following quantities:

[1]A licensee whose license expires or terminates prior to, or on the last day of the calendar year, shall submit reports at the expiration or termination of the license, covering that part of the year during which the license was in effect.

Radionuclide [1]	Quantity in curies
Cesium-137	1
Cobalt-60	1
Gold-198	100
Iodine-131	1
Indium-192	10
Krypton-85	1,000
Promethium-147	10
Technetium-99m	1,000

[1] The Commission may require, as a license condition, or by rule, regulation or order pursuant to § 20.502, reports from licensees who are licensed to use radionuclides not on this list, in quantities sufficient to cause comparable radiation levels.

(7) Receive radioactive waste from other persons for disposal under Part 61 of this chapter.

(b) When an individual terminates employment with a licensee describe in paragraph (a) of this section, or an individual assigned to work in such a licensee's facility but not employed by the licensee, completes the work assignment in the licensee's facility, the licensee shall furnish to the Director of Management and Program Analysis, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, a report of the individual's exposures to radiation and radioactive material, incurred during the period of employment or work assignment in the licensee's facility, containing information recorded by the licensee pursuant to §§ 20.401(a) and 20.108. Such report shall be furnished within 30 days after the exposure of the individual has been determined by the licensee or 90 days after the date of termination of employment or work assignment, whichever is earlier.

[1] The Commission will evaluate the data obtained for 1978 and 1979 pursuant to this paragraph, and the benefits derived therefrom and may take action, including publication of notice of proposed rulemaking, to extend or otherwise modify this reporting requirement.

§ 20.409 Notifications and reports to individuals

(a) Requirements for notifications and reports to individuals of exposure to radiation or radioactive material are specified in § 19.13 of this chapter.

(b) When a licensee is required pursuant to §§ 20.405 or 20.408 to report to the Commission any exposure of an individual to radiation or radioactive material, the licensee shall also notify the individual. Such notice shall be transmitted at a time not later than the transmittal to the Commission, and shall comply with the provisions of § 19.13(a) of this chapter.

Exceptions and Additional Requirements

§ 20.501 Applications for exemptions.

The Commission may, upon application by any licensee or upon its own initiative, grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not result in undue hazard to life or property.

§ 20.502 Additional requirements.

The Commission may, by rule, regulation, or order, impose upon any licensee such requirements, in addition to those established in the regulations in this part, as it deems appropriate or necessary to protect health or to minimize danger to life or property.

Enforcement

§ 20.601 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Atomic Energy Act of 1954, as amended, or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act, or section 206 of the Energy Reorganization Act of 1974, or any rule, regulation, or order issued thereunder, or any term, condition, or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction, may be punished by fine or imprisonment or both, as provided by law.

NOTE: The reporting and record keeping requirements contained in this part have been approved by the General Accounting Office under B-180225 (R0043), (R0044), and (R0084).

APPENDIX A.—PROTECTION FACTORS FOR RESPIRATORS [1]

Description [2]	Mode [3]	Protection factors [4]		Tests and certified equipment—National Institute for Occupational Safety and Health/Mine Safety and Health Administration tests for permissibility
		Particulates only	Particulates, gases and vapors [5]	
I. Air-purifying respirators [6]				
Facepiece, half-mask [7]	HF	10		30 CFR Part 11, Subpart K.
Facepiece, full	FF	50		
Facepiece, half-mask, full, or hood	PP	1,000		
II. Atmosphere-supplying respirators				
1. Air-line respirator				
Facepiece, half-mask	CF		1,000	
Facepiece, half-mask	D		5	
Facepiece, full	CF		5,000	
Facepiece, full	D		5	30 CFR Part 11, Subpart J.
Facepiece, full	PD		5,000	
Hood	CF		(8)	
Suit	CF		(8)	(8)
2. Self-contained breathing apparatus (SCBA)				
Facepiece, full	D		50	
Facepiece, full	PD		[9] 10,000	30 CFR Part 11, Subpart H.
Facepiece, full	RD		50	
Facepiece, full	PP		[10] 5,000	
III. Combination respirator. Any combination of air-purifying and atmosphere-supplying respirators.			[11]	30 CFR Part 11, § 11.86(a).

[1] For use in the selection of respiratory protective devices to be used only where the contaminants have been identified and the concentrations for possible concentrations are known.

[2] Only for device types and modes having approval with the use of breathing equipment against the skin. Hoods and suits are exceptions.

[3] The mode symbols are defined as follows: CF = continuous flow; D = demand; PP = positive pressure (i.e., positive pressure during inhalation); PD = pressure demand (i.e., always positive pressure); RD = demand, recirculating (closed circuit); RP = positive pressure, recirculating (closed circuit).

[4] The protection factor is a measure of the degree of protection afforded by a respirator, defined as the ratio of the concentration of airborne radioactive material outside the respiratory protective equipment to that inside the equipment (usually inside the facepiece) under conditions of use. It is applied to the ambient airborne concentration to estimate the concentration inhaled by the wearer according to the following formula:

Concentration inhaled = Ambient airborne concentration / Protection factor

[5] The protection factors listed:

(a) Only for trained individuals wearing properly fitted respirators used and maintained under supervision in a well-planned respirator protective program.

(b) For air-purifying respirators only, when high efficiency particulate filters (efficiency 99.97% removal efficiency by thermally generated 0.3 μm dioctyl phthalate (DOP) test) are used in atmospheres not deficient in oxygen and not containing radioactive gas or vapor contaminants.

(c) No allowance is to be made for the use of canisters against radioactive gases or vapors.

(d) For atmosphere-supplying respirators only when supplied with adequate respirable air. Respirable air shall be provided of the quality and quantity required in accordance with NIOSH/MSHA respiration standards in 30 CFR Part 11. Oxygen shall not be used in the open apparatus.

[6] Assessing radioactive contaminants that present an absorption or submersion hazard. For inhaled gases, approximately one half of the intake occurs by absorption through the skin so that an overall protection factor of less than 2 is appropriate when air-supplying respirators are used to protect against inhaled gases. If the protection factor for a device is 5, the effective protection factor to inhaled gases is about 1.4; for devices with protection factors of 10 the effective factor to inhaled gases is about 1.7; and for devices with protection factors of 100 or more the effective factor to inhaled gases is about 1.9. Air-purifying respirators are not suitable for protection against inhaled gases. See also footnote 1 concerning suppressed-air suits.

[7] Corrosion and corrodible metal will not be used beyond service-life limitations.

[8] Under shop tests only. This type of respirator is not satisfactory for use where it might be possible (e.g., if an accident or emergency were to occur) for the ambient airborne concentration to reach instantaneous values greater than 10 times the permissible values in Table 1, Column 1 of Appendix B of this part. This type of respirator is not suitable for protection against plutonium or other high-toxicity materials. The mask shall be tested for fit with inward breath, prior to use, each time it is donned.

[9] Equipment shall be operated in a manner that ensures that proper air flow rates are maintained. A protection factor of no more than 1000 may be used for tested-and-certified supplied-air hoods when a minimum air flow of 6 cubic feet per minute is maintained and calibrated airline pressure gauges or flow measuring devices are used. A protection factor of up to 2000 may be used for tested and certified hoods only when the air flow is maintained at the manufacturer's recommended maximum rate for the equipment, the rate is greater than 6 cubic feet per minute, and calibrated airline pressure gauges or flow measuring devices are used.

The design of the suppressed-air hood or helmet (with a minimum flow of 6 cfm or 47) may determine to avoid effusion and the protection it provides. For example, some hoods capture contaminated air into the breathing zone when the wearer works with hands-over-head. This aspiration may be overcome if a short rope-like extension to the hood is worn under a tight or elastic. Other limitations specified by the approval agency shall be considered before using a hood in certain types of atmospheres, such as the design and its permeability to the contaminant under conditions of use.

[10] Appropriate protection factors shall be determined from 30 189(a)(i), taking into account the design of the suit and its permeability to the contaminant under conditions of use. There shall be a standby rescue person equipped with self-contained breathing apparatus and communications equipment whenever suppressed-air suits are used.

[11] No approved specifications are currently available for this equipment. Equipment shall be evaluated by testing or on the basis of reliable test information.

[12] This type of respirator may provide greater protection and be used for an emergency device in unknown concentrations for protection against inhalation hazards. External radiation hazards and other limitations to permitted exposure such as skin absorption shall be taken into account in these circumstances.

[13] Quantitative fit testing shall be performed on each individual and no more than 0.02% leakage is allowed with this type of apparatus. Permissible outward leakage of gas from this or any positive pressure self-contained breathing apparatus is unacceptable because service life will be reduced substantially. Special training in the use of this type of apparatus shall be provided to the wearer (see footnote 6).

[14] Protection factor for type and mode of operation as listed above.

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Note 1.—Protection factors for respirators, as may be approved by the U.S. Bureau of Mines/National Institute for Occupational Safety and Health (NIOSH) according to applicable approvals for respirators for type and mode of use to protect against airborne radionuclides, may be used to the extent that they do not exceed the protection factors listed in this table. The protection factors listed in this table may not be appropriate to circumstances where chemical or other respiratory hazards exist in addition to radiological hazards. The selection and use of respirators for these circumstances should take into account applicable approvals of the U.S. Bureau of Mines/NIOSH.

Note 2.—Radioactive contaminants for which the concentration values in Table 1, column 1, Appendix B of this part are based on internal dose due to inhalation may, in addition, present external exposure hazards at higher concentrations. Under these circumstances, limitations on occupancy may have to be governed by external dose limits.

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APPENDIX B

Concentrations in Air and Water Above Natural Background

[See notes at end of appendix]

Element (atomic number)	Isotope [1]	†	Table I, Column 1 Air (μCi/ml)	Table I, Column 2 Water (μCi/ml)	Table II, Column 1 Air (μCi/ml)	Table II, Column 2 Water (μCi/ml)
Actinium (89)	Ac 227	S	2×10^{-12}	6×10^{-3}	8×10^{-14}	2×10^{-4}
		I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228	S	8×10^{-9}	3×10^{-3}	3×10^{-9}	9×10^{-5}
		I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Americium (95)	Am 241	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 242m	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	2×10^{-10}	3×10^{-3}	9×10^{-12}	9×10^{-5}
	Am 242	S	4×10^{-8}	4×10^{-3}	1×10^{-9}	1×10^{-4}
		I	5×10^{-8}	4×10^{-3}	2×10^{-9}	1×10^{-4}
	Am 243	S	6×10^{-12}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Am 244	S	4×10^{-8}	1×10^{-1}	1×10^{-7}	5×10^{-3}
		I	2×10^{-8}	1×10^{-1}	8×10^{-7}	5×10^{-3}
Antimony (51)	Sb 122	S	2×10^{-7}	8×10^{-4}	6×10^{-9}	3×10^{-5}
		I	1×10^{-7}	8×10^{-4}	5×10^{-9}	3×10^{-5}
	Sb 124	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	2×10^{-8}	7×10^{-4}	7×10^{-10}	2×10^{-5}
	Sb 125	S	3×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	3×10^{-8}	3×10^{-3}	9×10^{-10}	1×10^{-4}
Argon (18)	A 37	Sub [2]	6×10^{-3}		1×10^{-4}	
	A 41	Sub	2×10^{-6}		4×10^{-8}	
Arsenic (33)	As 73	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	5×10^{-4}
		I	4×10^{-7}	1×10^{-2}	1×10^{-8}	5×10^{-4}
	As 74	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	5×10^{-5}
		I	1×10^{-7}	2×10^{-3}	4×10^{-9}	5×10^{-5}
	As 76	S	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
		I	1×10^{-7}	6×10^{-4}	3×10^{-9}	2×10^{-5}
	As 77	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
Astatine (85)	At 211	S	7×10^{-6}	5×10^{-3}	2×10^{-10}	2×10^{-4}
		I	3×10^{-6}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Barium (56)	Ba 131	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ba 140	S	1×10^{-7}	8×10^{-4}	4×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	2×10^{-5}
Berkelium (97)	Bk 249	S	9×10^{-10}	2×10^{-1}	3×10^{-11}	6×10^{-4}
		I	1×10^{-7}	2×10^{-1}	4×10^{-9}	6×10^{-4}
	Bk 250	S	1×10^{-7}	6×10^{-3}	5×10^{-9}	2×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Beryllium (4)	Be 7	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	2×10^{-3}
		I	1×10^{-6}	3×10^{-2}	4×10^{-8}	2×10^{-3}
Bismuth (83)	Bi 206	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
		I	1×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Bi 207	S	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
		I	1×10^{-7}	2×10^{-3}	5×10^{-10}	6×10^{-5}
	Bi 210	S	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
		I	6×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}
	Bi 212	S	1×10^{-7}	1×10^{-3}	3×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I, Column 1 Air (μCi/ml)	Table I, Column 2 Water (μCi/ml)	Table II, Column 1 Air (μCi/ml)	Table II, Column 2 Water (μCi/ml)
Bromine (35)	Br 82	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	3×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Cadmium (48)	Cd 109	S	3×10^{-6}	5×10^{-3}	2×10^{-8}	2×10^{-4}
		I	7×10^{-8}	5×10^{-3}	3×10^{-9}	2×10^{-4}
	Cd 115m	S	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
		I	4×10^{-8}	7×10^{-4}	1×10^{-9}	3×10^{-5}
	Cd 115	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
Calcium (20)	Ca 45	S	3×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-7}	5×10^{-3}	4×10^{-9}	2×10^{-4}
	Ca 47	S	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	3×10^{-5}
Californium (98)	Cf 249	S	2×10^{-12}	1×10^{-4}	5×10^{-14}	4×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cf 250	S	5×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-5}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 251	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cf 252	a S	6×10^{-13}	2×10^{-4}	2×10^{-13}	7×10^{-6}
		a I	3×10^{-11}	2×10^{-4}	1×10^{-12}	7×10^{-6}
	Cf 253	S	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
		I	8×10^{-10}	4×10^{-3}	3×10^{-11}	1×10^{-4}
	Cf 254	S	3×10^{-13}	4×10^{-4}	2×10^{-13}	1×10^{-7}
		I	3×10^{-12}	4×10^{-4}	2×10^{-13}	1×10^{-7}
Carbon (6)	C 14 (CO_2)	S	4×10^{-6}	2×10^{-3}	1×10^{-7}	8×10^{-4}
		Sub	3×10^{-5}		1×10^{-6}	
Cerium (58)	Ce 141	S	4×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	3×10^{-3}	5×10^{-9}	9×10^{-5}
	Ce 143	S	3×10^{-7}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
	Ce 144	S	1×10^{-8}	3×10^{-4}	3×10^{-10}	1×10^{-5}
		I	6×10^{-9}	3×10^{-4}	2×10^{-10}	1×10^{-5}
Cesium (55)	Cs 131	S	1×10^{-5}	7×10^{-3}	4×10^{-7}	2×10^{-3}
		I	3×10^{-6}	3×10^{-3}	1×10^{-7}	9×10^{-4}
	Cs 134m	S	4×10^{-5}	2×10^{-1}	1×10^{-6}	6×10^{-3}
		I	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	Cs 134	S	4×10^{-8}	3×10^{-4}	1×10^{-9}	9×10^{-6}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	4×10^{-5}
	Cs 135	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	9×10^{-8}	7×10^{-3}	3×10^{-9}	2×10^{-4}
	Cs 136	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	9×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-9}	6×10^{-5}
	Cs 137	S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Chlorine (17)	Cl 36	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
		I	2×10^{-6}	2×10^{-3}	8×10^{-10}	6×10^{-5}
	Cl 38	S	3×10^{-6}	1×10^{-3}	9×10^{-9}	4×10^{-5}
		I	2×10^{-6}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Chromium (24)	Cr 51	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-3}
		I	2×10^{-6}	5×10^{-2}	8×10^{-9}	2×10^{-3}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Cobalt (27)	Co 57	S	3×10^{-6}	2×10^{-2}	1×10^{-7}	5×10^{-4}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-5}
	Co 58m	S	2×10^{-5}	8×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	6×10^{-3}	3×10^{-7}	2×10^{-4}
	Co 58	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	3×10^{-6}	2×10^{-3}	2×10^{-8}	9×10^{-5}
	Co 60	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	9×10^{-6}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Copper (29)	Cu 64	S	2×10^{-6}	1×10^{-2}	7×10^{-8}	3×10^{-4}
		I	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
Curium (96)	Cm 242	S	1×10^{-10}	7×10^{-4}	4×10^{-12}	2×10^{-5}
		W [2] I	2×10^{-10}	7×10^{-4}	6×10^{-12}	2×10^{-5}
	Cm 243	S	6×10^{-11}	1×10^{-4}	2×10^{-12}	5×10^{-6}
		I	1×10^{-10}	7×10^{-4}	3×10^{-12}	2×10^{-5}
	Cm 244	S	9×10^{-11}	2×10^{-4}	3×10^{-12}	7×10^{-6}
		I	1×10^{-10}	8×10^{-4}	3×10^{-12}	3×10^{-5}
	Cm 245	S	5×10^{-11}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 246	S	5×10^{-11}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
	Cm 247	S	5×10^{-11}	1×10^{-4}	2×10^{-13}	4×10^{-6}
		I	1×10^{-10}	6×10^{-4}	4×10^{-12}	2×10^{-5}
	Cm 248	S	6×10^{-13}	1×10^{-5}	2×10^{-14}	4×10^{-7}
		I	1×10^{-11}	4×10^{-5}	4×10^{-13}	1×10^{-6}
	Cm 249	S	1×10^{-7}	6×10^{-3}	4×10^{-7}	2×10^{-3}
		I	1×10^{-7}	6×10^{-3}	4×10^{-7}	2×10^{-3}
Dysprosium (66)	Dy 165	S	5×10^{-6}	1×10^{-2}	9×10^{-8}	4×10^{-4}
		I	2×10^{-6}	1×10^{-2}	7×10^{-8}	4×10^{-4}
	Dy 166	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Einsteinium (99)	Es 253	S	8×10^{-10}	7×10^{-4}	3×10^{-11}	2×10^{-5}
		I	6×10^{-10}	7×10^{-4}	2×10^{-11}	2×10^{-5}
	Es 254m	S	5×10^{-8}	5×10^{-4}	2×10^{-10}	2×10^{-5}
		I	6×10^{-8}	5×10^{-4}	2×10^{-10}	2×10^{-5}
	Es 254	S	2×10^{-11}	4×10^{-4}	6×10^{-13}	1×10^{-5}
		I	1×10^{-10}	4×10^{-4}	4×10^{-12}	1×10^{-5}
	Es 255	S	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
		I	4×10^{-10}	8×10^{-4}	1×10^{-11}	3×10^{-5}
Erbium (68)	Er 169	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-5}
	Er 171	S	7×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Europium (63)	Eu 152	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	(T/2 = 9.2 hrs)	I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Eu 152	S	1×10^{-6}	2×10^{-3}	4×10^{-10}	8×10^{-5}
	(T/2 = 13 yrs)	I	2×10^{-6}	2×10^{-3}	6×10^{-10}	8×10^{-5}
	Eu 154	S	4×10^{-7}	6×10^{-4}	1×10^{-10}	2×10^{-5}
		I	7×10^{-7}	6×10^{-4}	2×10^{-10}	2×10^{-5}
	Eu 155	S	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}
		I	7×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-4}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

(See notes at end of appendix)

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Promium (100)	Pm 254	S	6×10^{-8}	4×10^{-3}	2×10^{-7}	1×10^{-4}
		I	7×10^{-8}	4×10^{-3}	2×10^{-7}	1×10^{-4}
	Pm 255	S	2×10^{-8}	1×10^{-3}	6×10^{-10}	3×10^{-5}
		I	1×10^{-8}	1×10^{-3}	4×10^{-10}	3×10^{-5}
	Pm 256	S	3×10^{-8}	3×10^{-3}	1×10^{-10}	9×10^{-7}
		I	2×10^{-8}	3×10^{-3}	6×10^{-11}	9×10^{-7}
Fluorine (9)	F 18	S	5×10^{-6}	2×10^{-1}	2×10^{-7}	6×10^{-4}
		I	3×10^{-6}	1×10^{-1}	9×10^{-8}	3×10^{-4}
Gadolinium (64)	Gd 153	S	2×10^{-7}	6×10^{-3}	8×10^{-9}	2×10^{-5}
		I	9×10^{-8}	6×10^{-3}	3×10^{-9}	2×10^{-5}
	Gd 159	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	8×10^{-6}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-6}
Gallium (31)	Ga 72	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-6}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	4×10^{-6}
Germanium (32)	Ge 71	S	1×10^{-5}	5×10^{-2}	4×10^{-7}	2×10^{-4}
		I	6×10^{-6}	5×10^{-2}	2×10^{-7}	2×10^{-4}
Gold (79)	Au 196	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-5}
		I	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-5}
	Au 198	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-6}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	8×10^{-6}
	Au 199	S	1×10^{-6}	8×10^{-3}	4×10^{-8}	2×10^{-5}
		I	8×10^{-7}	4×10^{-3}	3×10^{-8}	2×10^{-5}
Hafnium (72)	Hf 181	S	4×10^{-8}	2×10^{-3}	1×10^{-9}	7×10^{-6}
		I	7×10^{-8}	2×10^{-3}	3×10^{-9}	7×10^{-6}
Holmium (67)	Ho 166	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-6}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-6}
Hydrogen (1)	H3	S	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-4}
		I	5×10^{-6}	1×10^{-1}	2×10^{-7}	3×10^{-4}
		Sub	2×10^{-3}		4×10^{-5}	
Indium (49)	In 113m	S	8×10^{-6}	4×10^{-2}	3×10^{-7}	1×10^{-4}
		I	7×10^{-6}	4×10^{-2}	2×10^{-7}	1×10^{-4}
	In 114m	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-6}
		I	2×10^{-6}	5×10^{-4}	7×10^{-10}	2×10^{-6}
	In 115m	S	2×10^{-6}	1×10^{-2}	8×10^{-9}	4×10^{-5}
		I	2×10^{-6}	1×10^{-2}	6×10^{-9}	4×10^{-5}
	In 115	S	2×10^{-7}	2×10^{-3}	9×10^{-9}	9×10^{-6}
		I	3×10^{-9}	3×10^{-3}	1×10^{-9}	9×10^{-6}
Iodine (53)	I 125	S	5×10^{-9}	4×10^{-5}	8×10^{-11}	2×10^{-7}
		I	2×10^{-7}	6×10^{-3}	6×10^{-9}	2×10^{-5}
	I 126	S	8×10^{-9}	5×10^{-5}	9×10^{-11}	3×10^{-7}
		I	3×10^{-7}	3×10^{-3}	1×10^{-8}	9×10^{-6}
	I 129	S	2×10^{-9}	1×10^{-5}	2×10^{-11}	6×10^{-8}
		I	7×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-6}
	I 131	S	9×10^{-9}	6×10^{-5}	1×10^{-10}	3×10^{-7}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-6}
	I 132	S	2×10^{-7}	2×10^{-3}	3×10^{-9}	8×10^{-6}
		I	9×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-5}
	I 133	S	3×10^{-8}	2×10^{-4}	4×10^{-10}	1×10^{-6}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-6}
	I 134	S	5×10^{-7}	4×10^{-3}	6×10^{-9}	2×10^{-5}

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[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Iodine (53)	I 134	D	3×10^{-6}	2×10^{-3}	1×10^{-7}	6×10^{-6}
	I 135	S	1×10^{-7}	7×10^{-6}	1×10^{-8}	4×10^{-6}
		I	4×10^{-7}	3×10^{-3}	1×10^{-8}	7×10^{-3}
Iridium (77)	Ir 190	S	1×10^{-6}	6×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Ir 192	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	3×10^{-8}	1×10^{-3}	9×10^{-10}	4×10^{-5}
	Ir 194	S	2×10^{-7}	1×10^{-3}	8×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
Iron (26)	Fe 55	S	9×10^{-7}	2×10^{-3}	3×10^{-8}	8×10^{-5}
		I	1×10^{-6}	7×10^{-3}	3×10^{-8}	2×10^{-4}
	Fe 59	S	1×10^{-7}	2×10^{-3}	5×10^{-9}	6×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	5×10^{-5}
Krypton (36)	Kr 85m	Sub	6×10^{-6}	.....	1×10^{-7}	.....
	Kr 85	Sub	1×10^{-5}	.....	3×10^{-7}	.....
	Kr 87	Sub	1×10^{-6}	.....	2×10^{-8}	.....
	Kr 88	Sub	1×10^{-6}	.....	2×10^{-8}	.....
Lanthanum (57)	La 140	S	2×10^{-7}	7×10^{-4}	5×10^{-9}	2×10^{-5}
		I	1×10^{-7}	7×10^{-4}	4×10^{-9}	2×10^{-5}
Lead (82)	Pb 203	S	3×10^{-6}	1×10^{-3}	9×10^{-8}	4×10^{-5}
		I	2×10^{-6}	1×10^{-3}	6×10^{-8}	4×10^{-5}
	Pb 210	S	1×10^{-10}	4×10^{-6}	4×10^{-12}	1×10^{-7}
		I	2×10^{-10}	5×10^{-3}	8×10^{-12}	2×10^{-4}
	Pb 212	S	2×10^{-6}	6×10^{-4}	6×10^{-10}	2×10^{-5}
		I	2×10^{-8}	5×10^{-4}	7×10^{-10}	2×10^{-5}
Lutetium (71)	Lu 177	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Manganese (25)	Mn 52	S	2×10^{-7}	1×10^{-3}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	9×10^{-4}	5×10^{-9}	3×10^{-5}
	Mn 54	S	4×10^{-7}	4×10^{-3}	1×10^{-8}	1×10^{-4}
		I	4×10^{-8}	3×10^{-3}	1×10^{-8}	1×10^{-4}
	Mn 56	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Mercury (80)	Hg 197m	S	7×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
		I	8×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
	Hg 197	S	1×10^{-6}	9×10^{-3}	4×10^{-8}	3×10^{-4}
		I	3×10^{-6}	1×10^{-2}	9×10^{-8}	5×10^{-4}
	Hg 203	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
Molybdenum (42)	Mo 99	S	7×10^{-7}	5×10^{-3}	3×10^{-8}	2×10^{-4}
		I	2×10^{-7}	1×10^{-3}	7×10^{-9}	4×10^{-5}
Neodymium (60)	Nd 144	S	8×10^{-11}	2×10^{-3}	3×10^{-12}	7×10^{-5}
		I	3×10^{-10}	2×10^{-3}	1×10^{-11}	8×10^{-5}
	Nd 147	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	2×10^{-3}	8×10^{-9}	6×10^{-5}
	Nd 149	S	2×10^{-6}	8×10^{-3}	6×10^{-8}	3×10^{-4}
		I	1×10^{-6}	8×10^{-3}	5×10^{-8}	3×10^{-4}

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Concentrations in Air and Water Above Natural Background--Continued

[See notes at end of appendix]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Neptunium (93)	Np 237	S	4×10^{-12}	9×10^{-8}	1×10^{-13}	3×10^{-9}
		I	1×10^{-10}	9×10^{-6}	4×10^{-12}	3×10^{-7}
	Np 239	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	7×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
Nickel (28)	Ni 59	S	5×10^{-7}	6×10^{-3}	2×10^{-8}	2×10^{-4}
		I	8×10^{-7}	6×10^{-3}	3×10^{-8}	2×10^{-4}
	Ni 63	S	6×10^{-8}	8×10^{-4}	2×10^{-9}	3×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
	Ni 65	S	9×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Niobium (Columbium) (41)	Nb 93m	S	1×10^{-7}	1×10^{-3}	4×10^{-9}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	5×10^{-9}	4×10^{-5}
	Nb 95	S	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	1×10^{-7}	3×10^{-3}	3×10^{-9}	1×10^{-4}
	Nb 97	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
		I	3×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
Osmium (76)	Os 185	S	5×10^{-7}	2×10^{-3}	2×10^{-8}	7×10^{-5}
		I	5×10^{-8}	2×10^{-3}	2×10^{-9}	7×10^{-5}
	Os 191m	S	2×10^{-5}	7×10^{-2}	6×10^{-7}	3×10^{-3}
		I	9×10^{-6}	7×10^{-2}	3×10^{-7}	2×10^{-3}
	Os 191	S	1×10^{-6}	5×10^{-3}	4×10^{-8}	2×10^{-4}
		I	4×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Os 193	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-9}	5×10^{-5}
Palladium (46)	Pd 103	S	1×10^{-6}	1×10^{-3}	5×10^{-8}	3×10^{-4}
		I	7×10^{-7}	8×10^{-4}	3×10^{-8}	3×10^{-4}
	Pd 109	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
Phosphorus (15)	P 32	S	7×10^{-8}	5×10^{-4}	2×10^{-9}	2×10^{-5}
		I	8×10^{-8}	7×10^{-4}	3×10^{-9}	2×10^{-5}
Platinum (78)	Pt 191	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
	Pt 193m	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
	★ Pt 193	S	1×10^{-5}	3×10^{-2}	4×10^{-7}	9×10^{-4}
		I	3×10^{-7}	5×10^{-3}	1×10^{-8}	2×10^{-4}
	Pt 197m	S	6×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	5×10^{-6}	3×10^{-2}	2×10^{-7}	9×10^{-4}
	Pt 197	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	6×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Plutonium (94)	Pu 238	S	2×10^{-12}	1×10^{-4}	7×10^{-14}	5×10^{-6}
		I	3×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 239	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 240	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	5×10^{-6}
		I	4×10^{-11}	8×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 241	S	9×10^{-11}	7×10^{-3}	3×10^{-12}	2×10^{-4}
		I	4×10^{-9}	4×10^{-3}	1×10^{-10}	1×10^{-3}

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[See notes at end of appendix]

Element (atomic number)	Isotope	†	Table I Column 1 Air (μCi/ml)	Table I Column 2 Water (μCi/ml)	Table II Column 1 Air (μCi/ml)	Table II Column 2 Water (μCi/ml)
Plutonium (94)	Pu 242	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	3×10^{-6}
		I	4×10^{-11}	9×10^{-4}	1×10^{-12}	3×10^{-5}
	Pu 243	S	2×10^{-9}	1×10^{-2}	6×10^{-8}	3×10^{-4}
		I	2×10^{-9}	1×10^{-2}	8×10^{-8}	3×10^{-4}
	Pu 244	S	2×10^{-12}	1×10^{-4}	6×10^{-14}	4×10^{-6}
		I	3×10^{-11}	3×10^{-4}	1×10^{-12}	1×10^{-5}
Polonium (84)	Po 210	S	3×10^{-10}	2×10^{-3}	2×10^{-11}	7×10^{-8}
		I	2×10^{-10}	8×10^{-4}	7×10^{-12}	2×10^{-5}
Potassium (19)	K 42	S	2×10^{-6}	9×10^{-3}	7×10^{-8}	3×10^{-4}
		I	1×10^{-7}	6×10^{-4}	4×10^{-9}	2×10^{-5}
Praseodymium (59)	Pr 142	S	2×10^{-7}	9×10^{-4}	7×10^{-9}	3×10^{-5}
		I	2×10^{-7}	9×10^{-4}	8×10^{-9}	3×10^{-5}
	Pr 143	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
		I	2×10^{-7}	1×10^{-3}	6×10^{-9}	5×10^{-5}
Promethium (61)	Pm 147	S	6×10^{-8}	6×10^{-3}	2×10^{-9}	2×10^{-4}
		I	1×10^{-7}	6×10^{-3}	3×10^{-9}	2×10^{-4}
	Pm 149	S	3×10^{-7}	1×10^{-3}	1×10^{-8}	4×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	4×10^{-5}
Protactinium (91)	Pa 230	S	2×10^{-8}	7×10^{-3}	6×10^{-11}	2×10^{-4}
		I	8×10^{-10}	7×10^{-3}	3×10^{-11}	2×10^{-4}
	Pa 231	S	1×10^{-13}	3×10^{-7}	4×10^{-14}	9×10^{-7}
		I	1×10^{-10}	8×10^{-4}	4×10^{-12}	2×10^{-5}
	Pa 233	S	6×10^{-7}	4×10^{-3}	2×10^{-8}	1×10^{-4}
		I	2×10^{-7}	3×10^{-3}	6×10^{-9}	1×10^{-4}
Radium (88)	Ra 223	S	2×10^{-8}	2×10^{-3}	6×10^{-11}	7×10^{-7}
		I	2×10^{-10}	1×10^{-4}	8×10^{-12}	4×10^{-6}
	Ra 224	S	5×10^{-8}	7×10^{-3}	2×10^{-10}	2×10^{-4}
		I	7×10^{-10}	2×10^{-4}	2×10^{-11}	8×10^{-6}
	Ra 226	S	3×10^{-11}	4×10^{-7}	3×10^{-13}	3×10^{-9}
		I	8×10^{-11}	9×10^{-4}	2×10^{-12}	3×10^{-5}
	Ra 228	S	7×10^{-11}	8×10^{-7}	2×10^{-12}	3×10^{-8}
		I	4×10^{-11}	7×10^{-4}	1×10^{-12}	3×10^{-5}
Radon (86)	Rn 220	S	3×10^{-7}		1×10^{-8}	
	Rn 222	***	*** 3×10^{-8}		3×10^{-9}	
Rhenium (75)	Re 183	S	3×10^{-6}	2×10^{-2}	9×10^{-8}	6×10^{-4}
		I	2×10^{-7}	8×10^{-3}	5×10^{-9}	3×10^{-4}
	Re 186	S	6×10^{-7}	3×10^{-3}	2×10^{-8}	9×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-5}
	Re 187	S	9×10^{-6}	7×10^{-2}	3×10^{-7}	3×10^{-3}
		I	5×10^{-7}	4×10^{-3}	2×10^{-8}	2×10^{-4}
	Re 188	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
		I	2×10^{-7}	9×10^{-4}	6×10^{-9}	3×10^{-5}
Rhodium (45)	Rh 103m	S	8×10^{-5}	4×10^{-1}	3×10^{-6}	1×10^{-2}
		I	6×10^{-6}	3×10^{-1}	2×10^{-7}	1×10^{-2}
	Rh 105	S	8×10^{-7}	4×10^{-3}	3×10^{-8}	1×10^{-4}
		I	5×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
Rubidium (37)	Rb 86	S	3×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	7×10^{-8}	7×10^{-4}	2×10^{-9}	2×10^{-5}
	Rb 87	S	9×10^{-7}	3×10^{-3}	2×10^{-8}	1×10^{-4}
		I	7×10^{-8}	5×10^{-3} •	2×10^{-9}	2×10^{-4}

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Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Ruthenium (44)	Ru 97	S	2×10^{-6}	1×10^{-3}	8×10^{-6}	4×10^{-3}
		I	2×10^{-6}	1×10^{-3}	6×10^{-6}	3×10^{-3}
	Ru 103	S	8×10^{-7}	2×10^{-3}	2×10^{-6}	6×10^{-3}
		I	8×10^{-6}	2×10^{-3}	3×10^{-6}	8×10^{-3}
	Ru 105	S	7×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-2}
		I	8×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-2}
	Ru 106	S	8×10^{-8}	4×10^{-4}	3×10^{-7}	1×10^{-3}
		I	6×10^{-6}	3×10^{-4}	2×10^{-6}	1×10^{-3}
Samarium (62)	Sm 147	S	9×10^{-11}	2×10^{-6}	2×10^{-10}	6×10^{-3}
		I	2×10^{-10}	2×10^{-6}	9×10^{-10}	7×10^{-3}
	Sm 151	S	6×10^{-6}	1×10^{-2}	2×10^{-5}	4×10^{-2}
		I	1×10^{-7}	1×10^{-2}	8×10^{-7}	4×10^{-2}
	Sm 153	S	5×10^{-7}	2×10^{-3}	2×10^{-6}	8×10^{-3}
		I	4×10^{-7}	2×10^{-3}	1×10^{-6}	8×10^{-3}
Scandium (21)	Sc 46	S	2×10^{-7}	1×10^{-3}	8×10^{-7}	4×10^{-3}
		I	2×10^{-6}	1×10^{-3}	6×10^{-10}	4×10^{-3}
	Sc 47	S	6×10^{-7}	3×10^{-3}	2×10^{-6}	9×10^{-3}
		I	8×10^{-7}	3×10^{-3}	2×10^{-6}	9×10^{-3}
	Sc 48	S	5×10^{-7}	8×10^{-4}	6×10^{-7}	3×10^{-3}
		I	1×10^{-7}	8×10^{-4}	5×10^{-7}	3×10^{-3}
Selenium (34)	Se 75	S	1×10^{-6}	9×10^{-3}	4×10^{-6}	3×10^{-2}
		I	1×10^{-7}	9×10^{-3}	4×10^{-7}	3×10^{-2}
Silicon (14)	Si 31	S	6×10^{-6}	3×10^{-3}	2×10^{-7}	9×10^{-3}
		I	1×10^{-6}	6×10^{-3}	3×10^{-6}	2×10^{-2}
Silver (47)	Ag 105	S	6×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-2}
		I	8×10^{-6}	3×10^{-3}	3×10^{-6}	1×10^{-2}
	Ag 110m	S	2×10^{-7}	9×10^{-4}	7×10^{-7}	3×10^{-3}
		I	1×10^{-6}	9×10^{-4}	3×10^{-6}	3×10^{-3}
	Ag 111	S	3×10^{-7}	1×10^{-3}	1×10^{-6}	4×10^{-3}
		I	2×10^{-7}	1×10^{-3}	8×10^{-7}	4×10^{-3}
Sodium (11)	Na 22	S	2×10^{-7}	1×10^{-3}	6×10^{-7}	4×10^{-3}
		I	9×10^{-7}	9×10^{-4}	3×10^{-6}	3×10^{-3}
	Na 24	S	1×10^{-6}	6×10^{-4}	4×10^{-6}	2×10^{-3}
		I	1×10^{-7}	8×10^{-4}	5×10^{-7}	3×10^{-3}
Strontium (38)	Sr 85m	S	4×10^{-6}	2×10^{-2}	1×10^{-5}	7×10^{-2}
		I	2×10^{-6}	2×10^{-2}	1×10^{-5}	7×10^{-2}
	Sr 85	S	2×10^{-6}	3×10^{-3}	8×10^{-6}	1×10^{-2}
		I	1×10^{-7}	8×10^{-3}	4×10^{-6}	2×10^{-2}
	Sr 89	S	3×10^{-7}	2×10^{-3}	9×10^{-10}	3×10^{-3}
		I	4×10^{-7}	8×10^{-4}	1×10^{-6}	3×10^{-3}
	Sr 90	S	1×10^{-7}	1×10^{-4}	3×10^{-11}	3×10^{-4}
		I	8×10^{-6}	1×10^{-3}	2×10^{-9}	4×10^{-3}
	Sr 91	S	4×10^{-7}	2×10^{-3}	2×10^{-6}	7×10^{-3}
		I	3×10^{-7}	1×10^{-3}	9×10^{-7}	4×10^{-3}
	Sr 92	S	4×10^{-7}	2×10^{-3}	2×10^{-6}	7×10^{-3}
		I	3×10^{-7}	2×10^{-3}	1×10^{-6}	6×10^{-3}
Sulfur (16)	S 35	S	9×10^{-7}	2×10^{-3}	5×10^{-6}	6×10^{-3}
		I	2×10^{-7}	8×10^{-3}	9×10^{-6}	3×10^{-2}
Tantalum (73)	Ta 182	S	4×10^{-6}	1×10^{-3}	1×10^{-5}	4×10^{-3}
		I	2×10^{-6}	1×10^{-3}	7×10^{-6}	4×10^{-3}

APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix.]

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
		†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Yttrium (39)	Y 90m	S	8×10^{-6}	4×10^{-3}	3×10^{-8}	1×10^{-5}
		I	3×10^{-6}	3×10^{-3}	1×10^{-8}	1×10^{-5}
	Y 90	S	6×10^{-7}	3×10^{-3}	2×10^{-9}	1×10^{-5}
		I	2×10^{-7}	1×10^{-3}	8×10^{-9}	5×10^{-6}
	Y 91m	S	2×10^{-6}	1×10^{-2}	8×10^{-9}	4×10^{-5}
		I	6×10^{-7}	3×10^{-3}	3×10^{-9}	2×10^{-5}
	Y 91	S	1×10^{-7}	5×10^{-4}	4×10^{-10}	2×10^{-6}
		I	3×10^{-7}	2×10^{-3}	1×10^{-9}	8×10^{-6}
	Y 92	S	4×10^{-6}	2×10^{-2}	1×10^{-8}	6×10^{-5}
		I	1×10^{-6}	6×10^{-3}	5×10^{-9}	2×10^{-5}
	Y 93	S	2×10^{-6}	1×10^{-2}	7×10^{-9}	3×10^{-5}
		I	6×10^{-7}	3×10^{-3}	2×10^{-9}	2×10^{-5}
Zirconium (40)	Zr 95	S	4×10^{-7}	3×10^{-3}	1×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-10}	1×10^{-5}
	Zr 97	S	1×10^{-7}	2×10^{-3}	5×10^{-10}	6×10^{-6}
		I	4×10^{-8}	2×10^{-3}	1×10^{-10}	5×10^{-6}
Niobium (41)	Nb 95m	S	2×10^{-7}	8×10^{-3}	6×10^{-10}	3×10^{-5}
		I	9×10^{-7}	5×10^{-3}	3×10^{-9}	2×10^{-5}
	Nb 95	S	8×10^{-6}	1×10^{-2}	3×10^{-9}	3×10^{-5}
		I	3×10^{-6}	6×10^{-3}	1×10^{-9}	2×10^{-5}
	Nb 97	S	8×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-5}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-5}
Molybdenum (42)	Mo 99	S	4×10^{-7}	2×10^{-2}	1×10^{-9}	6×10^{-5}
		I	2×10^{-7}	1×10^{-2}	6×10^{-10}	4×10^{-5}
Technetium (43)	Tc 96m	S	2×10^{-6}	1×10^{-2}	7×10^{-9}	3×10^{-5}
		I	1×10^{-7}	6×10^{-3}	4×10^{-10}	2×10^{-5}
	Tc 96	S	1×10^{-7}	6×10^{-4}	4×10^{-10}	2×10^{-6}
		I	4×10^{-8}	2×10^{-3}	1×10^{-10}	6×10^{-6}
	Tc 97m	S	1×10^{-6}	6×10^{-3}	4×10^{-9}	2×10^{-5}
		I	4×10^{-7}	2×10^{-3}	1×10^{-9}	6×10^{-6}
	Tc 97	S	1×10^{-5}	8×10^{-3}	4×10^{-7}	2×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-9}	8×10^{-6}
	Tc 99m	S	4×10^{-6}	2×10^{-2}	1×10^{-8}	6×10^{-5}
		I	1×10^{-6}	6×10^{-3}	5×10^{-9}	2×10^{-5}
	Tc 99	S	2×10^{-6}	1×10^{-2}	7×10^{-9}	3×10^{-5}
		I	6×10^{-6}	8×10^{-3}	2×10^{-9}	2×10^{-5}
Tellurium (52)	Te 125m	S	4×10^{-7}	5×10^{-3}	1×10^{-9}	2×10^{-5}
		I	1×10^{-7}	3×10^{-3}	4×10^{-10}	1×10^{-5}
	Te 127m	S	1×10^{-7}	2×10^{-3}	5×10^{-10}	6×10^{-6}
		I	4×10^{-8}	2×10^{-3}	1×10^{-10}	5×10^{-6}
	Te 127	S	2×10^{-6}	8×10^{-3}	6×10^{-9}	3×10^{-5}
		I	9×10^{-7}	5×10^{-3}	3×10^{-9}	2×10^{-5}
	Te 129m	S	8×10^{-8}	1×10^{-2}	3×10^{-9}	3×10^{-5}
		I	3×10^{-7}	6×10^{-3}	1×10^{-9}	2×10^{-5}
	Te 129	S	8×10^{-6}	2×10^{-2}	2×10^{-7}	8×10^{-5}
		I	4×10^{-6}	2×10^{-2}	1×10^{-7}	8×10^{-5}
	Te 131m	S	4×10^{-7}	2×10^{-2}	1×10^{-9}	6×10^{-5}
		I	2×10^{-7}	1×10^{-2}	6×10^{-10}	4×10^{-5}
	Te 132	S	2×10^{-7}	9×10^{-4}	7×10^{-10}	3×10^{-6}
		I	1×10^{-7}	6×10^{-4}	4×10^{-10}	2×10^{-6}
Terbium (65)	Tb 160	S	1×10^{-7}	1×10^{-3}	3×10^{-10}	4×10^{-6}
		I	3×10^{-8}	1×10^{-3}	1×10^{-10}	4×10^{-6}
Thallium (81)	Tl 200	S	3×10^{-6}	1×10^{-2}	9×10^{-9}	4×10^{-5}
		I	1×10^{-6}	7×10^{-3}	4×10^{-9}	2×10^{-5}
	Tl 201	S	2×10^{-6}	9×10^{-3}	7×10^{-9}	3×10^{-5}
		I	9×10^{-7}	5×10^{-3}	3×10^{-9}	2×10^{-5}
	Tl 202	S	8×10^{-7}	4×10^{-3}	3×10^{-9}	1×10^{-5}
		I	2×10^{-7}	2×10^{-3}	6×10^{-10}	7×10^{-6}
	Tl 204	S	6×10^{-7}	3×10^{-3}	2×10^{-9}	1×10^{-5}
		I	3×10^{-7}	2×10^{-3}	9×10^{-10}	6×10^{-6}
Thorium (90)	• Th 227	S	3×10^{-10}	5×10^{-6}	1×10^{-11}	2×10^{-7}
		I	2×10^{-10}	5×10^{-6}	6×10^{-11}	2×10^{-7}
	Th 228	S	9×10^{-12}	2×10^{-6}	3×10^{-12}	7×10^{-8}
		I	6×10^{-10}	4×10^{-6}	2×10^{-11}	1×10^{-7}
	Th 230	S	2×10^{-12}	8×10^{-9}	8×10^{-14}	2×10^{-10}
		I	1×10^{-11}	9×10^{-6}	3×10^{-12}	3×10^{-8}
	• Th 231	S	1×10^{-6}	7×10^{-3}	5×10^{-8}	2×10^{-4}
		I	1×10^{-6}	7×10^{-3}	4×10^{-8}	2×10^{-4}
	Th 232	S	3×10^{-11}	8×10^{-9}	1×10^{-12}	2×10^{-10}
		I	3×10^{-11}	1×10^{-8}	1×10^{-12}	4×10^{-8}
	•• Th natural	S	6×10^{-11}	6×10^{-6}	2×10^{-12}	2×10^{-8}
		I	6×10^{-11}	6×10^{-6}	2×10^{-12}	2×10^{-8}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

[See notes at end of appendix]

Element (atomic number)		Isotope [1]		Table I		Table II	
				Column 1	Column 2	Column 1	Column 2
			†	Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Thorium (90)		Th 234	S	6×10^{-8}	3×10^{-4}	2×10^{-7}	2×10^{-7}
			I	3×10^{-8}	3×10^{-4}	1×10^{-7}	2×10^{-7}
Thulium (69)		Tm 170	S	4×10^{-8}	1×10^{-3}	1×10^{-7}	3×10^{-7}
			I	3×10^{-8}	1×10^{-3}	1×10^{-7}	3×10^{-7}
		Tm 171	S	1×10^{-7}	1×10^{-2}	4×10^{-7}	3×10^{-4}
			I	2×10^{-7}	1×10^{-2}	8×10^{-7}	3×10^{-4}
Tin (50)		Sn 113	S	4×10^{-7}	2×10^{-3}	1×10^{-6}	9×10^{-7}
			I	3×10^{-8}	2×10^{-3}	2×10^{-7}	8×10^{-7}
		Sn 125	S	1×10^{-7}	3×10^{-4}	4×10^{-7}	2×10^{-7}
			I	8×10^{-8}	3×10^{-4}	3×10^{-7}	2×10^{-7}
Tungsten (Wolfram) (74)		W 181	S	2×10^{-6}	1×10^{-2}	8×10^{-6}	4×10^{-4}
			I	1×10^{-7}	1×10^{-3}	4×10^{-7}	3×10^{-4}
		W 185	S	8×10^{-7}	4×10^{-3}	3×10^{-6}	1×10^{-4}
			I	1×10^{-7}	3×10^{-3}	4×10^{-7}	1×10^{-4}
		W 187	S	4×10^{-7}	2×10^{-3}	2×10^{-6}	7×10^{-5}
			I	3×10^{-7}	2×10^{-3}	1×10^{-6}	6×10^{-5}
Uranium (92)		U 230	S	3×10^{-10}	1×10^{-4}	1×10^{-11}	5×10^{-5}
			I	1×10^{-10}	1×10^{-4}	4×10^{-11}	4×10^{-5}
		U 232	S	1×10^{-10}	8×10^{-5}	3×10^{-12}	3×10^{-5}
			I	3×10^{-11}	8×10^{-5}	9×10^{-12}	3×10^{-5}
		U 233	S	5×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	oo	U 234	S[4]	6×10^{-10}	9×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	9×10^{-4}	4×10^{-12}	3×10^{-5}
	oo	U 235	S[4]	5×10^{-10}	8×10^{-4}	2×10^{-11}	3×10^{-5}
			I	1×10^{-10}	8×10^{-4}	4×10^{-12}	3×10^{-5}
		U 236	S	6×10^{-10}	1×10^{-3}	2×10^{-11}	4×10^{-5}
			I	1×10^{-10}	1×10^{-3}	4×10^{-12}	3×10^{-5}
	oo	U 238	S[4]	7×10^{-11}	1×10^{-3}	3×10^{-12}	4×10^{-5}
			I	1×10^{-10}	1×10^{-3}	5×10^{-12}	4×10^{-5}
		U 240	S	2×10^{-7}	1×10^{-3}	8×10^{-7}	3×10^{-5}
			I	2×10^{-7}	1×10^{-3}	6×10^{-7}	3×10^{-5}
	oo	U-natural	S[4]	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
			I	1×10^{-10}	1×10^{-3}	5×10^{-12}	3×10^{-5}
Vanadium (23)		V 48	S	2×10^{-7}	9×10^{-4}	6×10^{-7}	3×10^{-5}
			I	6×10^{-8}	8×10^{-4}	2×10^{-7}	3×10^{-5}
Xenon (54)		Xe 131m	Sub	2×10^{-6}		4×10^{-7}	
		Xe 133	Sub	1×10^{-6}		3×10^{-7}	
		Xe 133m	Sub	1×10^{-6}		3×10^{-7}	
		Xe 135	Sub	6×10^{-7}		1×10^{-7}	
Ytterbium (70)		Yb 175	S	7×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-4}
			I	6×10^{-7}	3×10^{-3}	2×10^{-6}	1×10^{-4}
Yttrium (39)		Y 90	S	1×10^{-7}	6×10^{-4}	4×10^{-6}	2×10^{-5}
			I	1×10^{-7}	6×10^{-4}	3×10^{-6}	2×10^{-5}
		Y 91m	S	2×10^{-6}	1×10^{-2}	8×10^{-7}	3×10^{-5}
			I	2×10^{-6}	1×10^{-2}	6×10^{-7}	3×10^{-5}
		Y 91	S	4×10^{-8}	8×10^{-4}	1×10^{-6}	3×10^{-5}
			I	3×10^{-8}	8×10^{-4}	1×10^{-6}	3×10^{-5}
		Y 92	S	4×10^{-7}	2×10^{-3}	1×10^{-6}	6×10^{-5}
			I	3×10^{-7}	2×10^{-3}	1×10^{-6}	6×10^{-5}
		Y 93	S	2×10^{-7}	8×10^{-4}	6×10^{-7}	3×10^{-5}
			I	1×10^{-7}	8×10^{-4}	5×10^{-7}	3×10^{-5}

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APPENDIX B

Concentrations in Air and Water Above Natural Background—Continued

Element (atomic number)	Isotope [1]		Table I		Table II	
			Column 1	Column 2	Column 1	Column 2
			Air (μCi/ml)	Water (μCi/ml)	Air (μCi/ml)	Water (μCi/ml)
Zinc (30)	Zn 65	S	1×10^{-7}	3×10^{-3}	4×10^{-9}	1×10^{-4}
		I	6×10^{-8}	5×10^{-3}	2×10^{-9}	2×10^{-4}
	Zn 69m	S	4×10^{-7}	2×10^{-3}	1×10^{-8}	7×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	6×10^{-5}
	Zn 69	S	7×10^{-6}	3×10^{-2}	2×10^{-7}	1×10^{-3}
		I	9×10^{-6}	5×10^{-2}	3×10^{-7}	2×10^{-3}
Zirconium (40)	Zr 93	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	8×10^{-5}
		I	3×10^{-7}	2×10^{-3}	1×10^{-8}	8×10^{-5}
	Zr 95	S	1×10^{-7}	2×10^{-3}	4×10^{-9}	6×10^{-5}
		I	3×10^{-8}	2×10^{-3}	1×10^{-9}	6×10^{-5}
	Zr 97	S	1×10^{-7}	5×10^{-4}	4×10^{-9}	2×10^{-5}
		I	9×10^{-8}	5×10^{-4}	3×10^{-9}	2×10^{-5}
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than 2 hours.		Sub	1×10^{-6}		3×10^{-8}	
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours.			3×10^{-8}	9×10^{-3}	1×10^{-10}	3×10^{-4}
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.			6×10^{-11}	4×10^{-7}	2×10^{-12}	3×10^{-8}

[1] Soluble (S), insoluble (I)
"Sub" means that values given are for submersion in a semispherical infinite cloud of airborne material.

[2] These radon concentrations are appropriate for protection from radon-222 combined with its short-lived daughters. Alternatively, the value in Table I may be replaced by one-third (⅓) "working level." (A "working level" is defined as any combination of short-lived radon-222 daughters, polonium-218, lead-214, bismuth-214 and polonium-214, in one liter of air, without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3×10^5 MeV of alpha particle energy.) The Table II value may be replaced by one-thirtieth (1/30) of a "working level." The limit on radon-222 concentrations in restricted areas may be based on an annual average.

‡4. For soluble mixtures of U-238, U-234 and U-235 in air chemical toxicity may be the limiting factor. If the percent by weight (enrichment) of U-235 is less than 5, the concentration value for a 40-hour workweek, Table I, is 0.2 milligrams uranium per cubic meter of air average. For any enrichment, the product of the average concentration and time of exposure during a 40-hour workweek shall not exceed 8×10^{-3} SA μCi-hr/ml, where SA is the specific activity of the uranium inhaled. The concentration value for Table II is 0.007 milligrams uranium per cubic meter of air. The specific activity for natural uranium is 6.77×10^{-7} curies per gram U. The specific activity for other mixtures of U-238, U-235 and U-234, if not known, shall be:

$SA = 3.6 \times 10^{-7}$ curies/gram U U-depleted
$SA = (0.4 + 0.38\ E + 0.0034\ E^2)\ 10^{-6}$ $E \geq 0.72$

where E is the percentage by weight of U-235, expressed as percent.

*Amended 37 FR 23319.
**Amended 39 FR 23990; footnote redesignated 40 FR 50704.
***Amended 40 FR 50704.
†Amended 38 FR 29314.
‡Amended 39 FR 25463; redesignated 40 FR 50704.

40 FR 50704
39 FR 23990
35 FR 10914

NOTE TO APPENDIX B

NOTE: In any case where there is a mixture in air or water of more than one radionuclide, the limiting values for purposes of this Appendix should be determined as follows:

1. If the identity and concentration of each radionuclide in the mixture are known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").

EXAMPLE: If radionuclides A, B, and C are present in concentrations C_A, C_B, and C_C, and if the applicable MPC's are MPC_A, and MPC_B, and MPC_C respectively, then the concentrations shall be limited so that the following relationship exists:

$$\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \frac{C_C}{MPC_C} \leq 1$$

2. If either the identity or the concentration of any radionuclide in the mixture is not known, the limiting values for purposes of Appendix B shall be:

a. For purposes of Table I, Col. 1—6×10^{-12}
b. For purposes of Table I, Col. 2—4×10^{-7}
c. For purposes of Table II, Col. 1—2×10^{-10}
d. For purposes of Table II, Col. 2—8×10^{-6}

3. If any of the conditions specified below are met, the corresponding values specified below may be used in lieu of those specified in paragraph 2 above.

a. If the identity of each radionuclide in the mixture is known but the concentration of one or more of the radionuclides in the mixture is not known, the concentration limit for the mixture is the limit specified in Appendix "B" for the radionuclide in the mixture having the lowest concentration limit; or

b. If the identity of each radionuclide in the mixture is not known, but it is known that certain radionuclides specified in Appendix "B" are not present in the mixture, the concentration limit for the mixture is the lowest concentration limit specified in Appendix "B" for any radionuclide which is not known to be absent from the mixture; or

Element (atomic number) and isotope	Table I		Table II	
	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
If it is known that Sr 90, I 125, I 126, I 129, I 131, (I 133, table II only), Pb 210, Po 210, At 211, Ra 223, Ra 224, Ra 226, Ac 227, Ra 228, Th 228, Pa 231, Th 232, Th-nat, Cm 248, Cf 254, and Fm 254 are not present	----------	9×10^{-9}	----------	3×10^{-7}
If it is known that Sr 90, I 125, I 126, I 129, (I 131, I 133, table II only), Pb 210, Po 210, Ra 223, Ra 226, Ra 228, Pa 231, Th-nat, Cm 248, Cf 254, and Fm 254 are not present	----------	6×10^{-9}	----------	2×10^{-7}
If it is known that Sr 90, I 129, (I 125, I 126, I 131, table II only), Pb 210, Ra 226, Ra 228, Cm 248, and Cf 254 are not present	----------	2×10^{-9}	----------	6×10^{-9}
If it is known that (I 129, table II only), Ra 226, and Ra 228 are not present	----------	2×10^{-9}	----------	1×10^{-9}
If it is known that alpha-emitters and Sr 90, I 129, Pb 210, Ac 227, Ra 228, Pa 230, Pu 241, and Bk 246 are not present	2×10^{-9}	----------	1×10^{-10}	----------
If it is known that alpha-emitters and Pb 210, Ac 227, Ra 228, and Pu 241 are not present	2×10^{-10}	----------	1×10^{-10}	----------
If it is known that alpha-emitters and Ac 227 are not present	2×10^{-11}	----------	1×10^{-11}	----------
If it is known that Ac 227, Th 230, Pa 231, Pu 238, Pu 239, Pu 240, Pu 242, Pu 244, Cm 248, Cf 249 and Cf 251 are not present	8×10^{-12}	----------	1×10^{-11}	----------

4. If a mixture of radionuclides consists of uranium and its daughters in ore dust prior to chemical separation of the uranium from the ore, the values specified below may be used for uranium and its daughters through radium-226, instead of those from paragraphs 1, 2, or 3 above.

a. For purposes of Table I, Col. 1—1×10^{-11} μCi/ml gross alpha activity; or 5×10^{-11} μCi/ml natural uranium; or 70 micrograms per cubic meter of air natural uranium.

b. For purposes of Table II, Col. 1—3×10^{-10} μCi/ml gross alpha activity; or 2×10^{-10} μCi/ml natural uranium; or 3 micrograms per cubic meter of air natural uranium.

5. For purposes of this Note, a radionuclide may be considered as not present in a mixture if (a) the ratio of the concentration of that radionuclide in the mixture (C_A) to the concentration limit for that radionuclide specified in Table II of Appendix B (MPC_A) does not exceed $\frac{1}{10}$ (i.e. $\frac{C_A}{MPC_A} \leq \frac{1}{10}$) and (b) the sum of such ratios for all the radionuclides considered as not present in the mixture does not exceed $\frac{1}{4}$ (i.e. $\frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \ldots \leq \frac{1}{4}$).

APPENDIX C

Material	Microcuries
Americium-241	.01
Antimony-122	100
Antimony-124	10
Antimony-126	10
Arsenic-73	100
Arsenic-74	10
Arsenic-76	10
Arsenic-77	100
Barium-131	10
Barium-133	10
Barium-140	10
Bismuth-210	1
Bromine-82	10
Cadmium-109	10
Cadmium-115m	10
Cadmium-115	100
Calcium-45	10
Calcium-47	10
Carbon-14	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Cesium-131	1,000
Cesium-134m	100
Cesium-134	1
Cesium-135	10
Cesium-136	10
Cesium-137	10
Chlorine-36	10
Chlorine-38	10
Chromium-51	1,000
Cobalt-58m	10
Cobalt-58	10
Cobalt-60	1
Copper-64	100
Dysprosium-165	10
Dysprosium-166	100
Erbium-169	100
Erbium-171	100
Europium-152 9.2 h	100
Europium-152 13 yr	1
Europium-154	1
Europium-155	10
Fluorine-18	1,000
Gadolinium-153	10
Gadolinium-159	100
Gallium-72	10
Germanium-71	100
Gold-198	100
Gold-199	100
Hafnium-181	10
Holmium-166	100
Hydrogen-3	1,000
Indium-113m	100
Indium-114m	10
Indium-115m	100
Indium-115	10
Iodine-125	1
Iodine-126	1
Iodine-129	0.1
Iodine-131	1
Iodine-132	10
Iodine-133	1
Iodine-134	10
Iodine-135	10
Iridium-192	10
Iridium-194	100
Iron-55	100
Iron-59	10
Krypton-85	100
Krypton-87	10
Lanthanum-140	10
Lutetium-177	100
Manganese-52	10
Manganese-54	10
Manganese-56	10
Mercury-197m	100
Mercury-197	100
Mercury-203	10
Molybdenum-99	100
Neodymium-147	100
Neodymium-149	100
Nickel-59	100
Nickel-63	10
Nickel-65	100
Niobium-93m	10
Niobium-95	10
Niobium-97	10
Osmium-185	10

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Material	Microcuries
Osmium-191m[1]	100
Osmium-191	100
Osmium-193	100
Palladium-109	100
Palladium-149	100
Phosphorus-32	10
Platinum-191	100
Platinum-193m	100
Platinum-193	100
Platinum-197m	100
Platinum-197	100
Plutonium-239	.01
Polonium-210	0.1
Potassium-42	10
Praseodymium-142	100
Praseodymium-143	100
Promethium-147	10
Promethium-149	10
Radium-226	.01
Rhenium-186	100
Rhenium-188	100
Rhodium-105m	100
Rhodium-105	100
Rubidium-86	10
Rubidium-87	10
Ruthenium-97	100
Ruthenium-103	10
Ruthenium-105	10
Ruthenium-106	1
Samarium-151	10
Samarium-153	100
Scandium-46	10
Scandium-47	100
Scandium-48	10
Selenium-75	10
Silicon-31	100
Silver-105	10
Silver-110m	1
Silver-111	100
Sodium-24	10
Strontium-85	10
Strontium-89	1
Strontium-90	0.1
Strontium-91	10
Strontium-92	10
Sulphur-35	100
Tantalum-182	10
Technetium-96	10
Technetium-97m	100
Technetium-97	100
Technetium-99m	100
Technetium-99	10
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	100
Tellurium-129m	10
Tellurium-129	100
Tellurium-131m	10
Tellurium-132	10
Terbium-160	10
Thallium-200	100
Thallium-201	100
Thallium-202	100
Thallium-204	10
★★Thorium (natural)[1]	100
Thulium-170	10
Thulium-171	10
Tin-113	10
Tin-125	10
Tungsten-181	10
Tungsten-185	10
Tungsten-187	100
★★Uranium (natural)[2]	100
Uranium-233	.01
Uranium-234 Uranium-238	.01
Vanadium-48	10
Xenon-131m	1,000
Xenon-133	100
Xenon-135	100
Ytterbium-175	100
Yttrium-90	10
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zirconium-93	10
Zirconium-95	10
Zirconium-97	10

35 FR 6425

Any alpha emitting radionuclide not listed above or mixtures of alpha emitters of unknown composition	.01
Any radionuclide other than alpha emitting radionuclides, not listed above or mixtures of beta emitters of unknown composition	.1

45 FR 71761

Note.—For purposes of § 20.303, where there is involved a combination of isotopes in known amounts, the limit for the combination should be derived as follows. Determine, for each isotope in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific isotope when not in combination. The sum of such ratios for all the isotopes in the combination may not exceed "1" (i.e., "unity").

[1] Based on alpha disintegration rate of Th-232, Th-230 and their daughter products.

[2] Based on alpha disintegration rate of U-238, U-234, and U-235.

* Amended 36 FR 16898.

** Amended 39 FR 23990.

48 FR 44172

APPENDIX D.—UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICES

	Address	Telephone (24 hrs)
Region I: Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.	USNRC, 631 Park Ave., King of Prussia, PA 19406	(215) 337-5000 (FTS) 488-1000.
Region II: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, Virgin Islands, and West Virginia.	USNRC, 101 Marietta Street, Suite 3100, Atlanta, GA 30303	(404) 221-4503. (FTS) 243-4503.
Region III: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.	USNRC, 799 Roosevelt Road, Glen Ellyn, IL 60137	(312) 790-5500. (FTS) 388-5500.
Region IV: Arkansas, Colorado, Idaho, Kansas, Louisiana, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas, Utah, and Wyoming.	USNRC, 611 Ryan Plaza Drive, Suite 1000, Arlington, TX 76011	(817) 860-8100. (FTS) 729-8100.
Region IV Field Office	USNRC, Region IV Uranium Recovery Field Office, 730 Simms Street, P.O. Box 25325, Denver, CO 80225.	(303) 234-7232. (FTS) 234-7232.
Region V: Alaska, Arizona, California, Hawaii, Nevada, Oregon, Washington, and U.S. territories and possessions in the Pacific.	USNRC, 1450 Maria Lane, Suite 210, Walnut Creek, CA 94596	(415) 943-3700. (FTS) 460-3700.

PART 30 • RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING...

Byproduct material	Microcuries
Cesium 134m (Cs 134m)	100
Cesium 134 (Cs 134)	1
Cesium 135 (Cs 135)	10
Cesium 136 (Cs 136)	10
Cesium 137 (Cs 137)	10
Chlorine 36 (Cl 36)	10
Chlorine 38 (Cl 38)	10
Chromium 51 (Cr 51)	1,000
Cobalt 58m (Co 58m)	10
Cobalt 58 (Co 58)	10
Cobalt 60 (Co 60)	1
Copper 64 (Cu 64)	100
Dysprosium 165 (Dy 165)	10
Dysprosium 166 (Dy 166)	100
Erbium 169 (Er 169)	100
Erbium 171 (Er 171)	100
Europium 152 9.2h (Eu 152 9.2h)	100
Europium 152 13 yr (Eu 152 13 yr)	1
Europium 154 (Eu 154)	1
Europium 155 (Eu 155)	10
Fluorine 18 (F 18)	1,000
Gadolinium 153 (Gd 153)	10
Gadolinium 159 (Gd 159)	100
Gallium 72 (Ga 72)	10
Germanium 71 (Ge 71)	100
Gold 198 (Au 198)	100
Gold 199 (Au 199)	100
Hafnium 181 (Hf 181)	10
Holmium 166 (Ho 166)	100
Hydrogen 3 (H 3)	1,000
Indium 113m (In 113m)	100
Indium 114m (In 114m)	10
Indium 115m (In 115m)	100
Indium 115 (In 115)	10
Iodine 125 (I 125)	1
Iodine 126 (I 126)	1
Iodine 129 (I 129)	0.1
Iodine 131 (I 131)	1
Iodine 132 (I 132)	10
Iodine 133 (I 133)	1
Iodine 134 (I 134)	10
Iodine 135 (I 135)	10
Iridium 192 (Ir 192)	10
Iridium 194 (Ir 194)	100
Iron 55 (Fe 55)	100
Iron 59 (Fe 59)	10
Krypton 85 (Kr 85)	100
Krypton 87 (Kr 87)	10
Lanthanum 140 (La 140)	10
Lutetium 177 (Lu 177)	100
Manganese 52 (Mn 52)	10
Manganese 54 (Mn 54)	10
Manganese 56 (Mn 56)	10
Mercury 197m (Hg 197m)	100
Mercury 197 (Hg 197)	100
Mercury 203 (Hg 203)	10
Molybdenum 99 (Mo 99)	100
Neodymium 147 (Nd 147)	100
Neodymium 149 (Nd 149)	100
Nickel 59 (Ni 59)	100
Nickel 63 (Ni 63)	10
Nickel 65 (Ni 65)	100
Niobium 93m (Nb 93m)	10
Niobium 95 (Nb 95)	10
Niobium 97 (Nb 97)	10
Osmium 185 (Os 185)	10
Osmium 191m (Os 191m)	100
Osmium 191 (Os 191)	100
Osmium 193 (Os 193)	100
Palladium 103 (Pd 103)	100
Palladium 109 (Pd 109)	100
Phosphorous 32 (P 32)	10
Platinum 191 (Pt 191)	100
Platinum 193m (Pt 193m)	100
Platinum 193 (Pt 193)	100
Platinum 197m (Pt 197m)	100
Platinum 197 (Pt 197)	100
Polonium 210 (Po 210)	0.1
Potassium 42 (K 42)	10
Praseodymium 142 (Pr 142)	100
Praseodymium 143 (Pr 143)	100
Promethium 147 (Pm 147)	10
Promethium 149 (Pm 149)	10
Rhenium 186 (Re 186)	100
Rhenium 188 (Re 188)	100
Rhodium 103m (Rh 103m)	100
Rhodium 105 (Rh 105)	100
Rubidium 86 (Rb 86)	10
Rubidium 87 (Rb 87)	10
Ruthenium 97 (Ru 97)	100
Ruthenium 103 (Ru 103)	10
Ruthenium 105 (Ru 105)	10
Ruthenium 106 (Ru 106)	1
Samarium 151 (Sm 151)	10
Samarium 153 (Sm 153)	100
Scandium 46 (Sc 46)	10
Scandium 47 (Sc 47)	100
Scandium 48 (Sc 48)	10
Selenium 75 (Sc 75)	10
Silicon 31 (Si 31)	100
Silver 105 (Ag 105)	10
Silver 110m (Ag 110m)	1
Silver 111 (Ag 111)	100
Sodium 24 (Na 24)	10
Strontium 85 (Sr 85)	10
Strontium 89 (Sr 89)	1
Strontium 90 (Sr 90)	0.1
Strontium 91 (Sr 91)	10
Strontium 92 (Sr 92)	10
Sulfur 35 (S 35)	100
Tantalum 182 (Ta 182)	10
Technetium 96 (Tc 96)	10
Technetium 97m (Tc 97m)	100
Technetium 97 (Tc 97)	100
Technetium 99m (Tc 99m)	100
Technetium 99 (Tc 99)	10
Tellurium 125m (Te 125m)	10
Tellurium 127m (Te 127m)	10
Tellurium 127 (Te 127)	100
Tellurium 129m (Te 129m)	10
Tellurium 129 (Te 129)	100
Tellurium 131m (Te 131m)	10
Tellurium 132 (Te 132)	10
Terbium 160 (Tb 160)	10
Thallium 200 (Tl 200)	100
Thallium 201 (Tl 201)	100
Thallium 202 (Tl 202)	100
Thallium 204 (Tl 204)	10
Thulium 170 (Tm 170)	10
Thulium 171 (Tm 171)	10
Tin 113 (Sn 113)	10
Tin 125 (Sn 125)	10
Tungsten 181 (W 181)	10
Tungsten 185 (W 185)	10
Tungsten 187 (W 187)	100
Vanadium 48 (V 48)	10
Xenon 131m (Xe 131m)	1,000
Xenon 133 (Xe 133)	100
Xenon 135 (Xe 135)	100
Ytterbium 175 (Yb 175)	100
Yttrium 90 (Y 90)	10
Yttrium 91 (Y 91)	10
Yttrium 92 (Y 92)	100
Yttrium 93 (Y 93)	100
Zinc 65 (Zn 65)	10
Zinc 69m (Zn 69m)	100
Zinc 69 (Zn 69)	1,000
Zirconium 93 (Zr 93)	10
Zirconium 95 (Zr 95)	10
Zirconium 97 (Zr 97)	10
Any byproduct material not listed above other than alpha emitting byproduct material	0.1

35 FR 6425 — 35 FR 6245 — 35 FR 6426 — 36 FR 16896

§ 30.71 Schedule B.

Byproduct material	Microcuries
Antimony 122 (Sb 122)	100
Antimony 124 (Sb 124)	10
Antimony 125 (Sb 125)	10
Arsenic 73 (As 73)	100
Arsenic 74 (As 74)	10
Arsenic 76 (As 76)	10
Arsenic 77 (As 77)	100
Barium 131 (Ba 131)	10
Barium 133 (Ba 133)	10
Barium 140 (Ba 140)	10
Bismuth 210 (Bi 210)	1
Bromine 82 (Br 82)	10
Cadmium 109 (Cd 109)	10
Cadmium 115m (Cd 115m)	10
Cadmium 115 (Cd 115)	100
Calcium 45 (Ca 45)	10
Calcium 47 (Ca 47)	10
Carbon 14 (C 14)	100
Cerium 141 (Ce 141)	100
Cerium 143 (Ce 143)	100
Cerium 144 (Ce 144)	1
Cesium 131 (Cs 131)	1,000

University of Wisconsin

NUCLEAR REACTOR LABORATORY
NUCLEAR ENGINEERING DEPARTMENT
PHONE 262-3392, AREA CODE 608

ADDRESS:
130 MECHANICAL ENGINEERING BUILDING
MADISON, WISCONSIN 53706

August 5, 1983

U. S. Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, Illinois 60137

Attn: Materials Licensing Section

Re: Control Number 22150, License SNM-116

Dear Sirs:

This letter replies to your request for additional information in letter form dated August 2, 1983. The responses below are numbered to correspond with the specific requests contained in the referenced letter.

1. Reference standards are stored in a designated drawer in a laboratory which is kept locked unless occupied by an authorized staff member. All other SNM is stored within the reactor laboratory security area. Reference standards are accounted for by the quarterly leak tests. The remaining SNM is inventoried semi-annually.

2. The attached document UWNR 100, section 6, specifies annual HP instrument calibrations and quarterly checks. The attached document UWNR 177 is the procedure for HP instrument checks and calibrations.

3. All staff members who routinely use and supervise use of the materials are issued R. S. Landauer, Jr. & Co. type Z (TLD, 3 chips), Fast Neutron (Neutrak 144) which are changed monthly. Students in our laboratory are issued type K (TLD, 3 chips) from the same vendor, which are also changed monthly. It is possible that the university will change vendors during the license period under the usual bid process, but dosimeters with similar capabilities would be used.

4. The attached document UWNR 176 details the leak testing procedure. The detector used to count the swipes is an Eberline Model FC-2 flow counter operated without a window. It is set up and calibrated by the Pu sources covered under license SNM-116.

5. If dissolution or chemical treatment of material is carried out under the license, contamination surveys are carried out at the end of each such procedure. Swipes are taken on a 100cm^2 area using alcohol saturated filter discs which are then allowed to dry and are counted in the detector referenced in item 4. The action level for decontamination is any detectable alpha activity picked up by the swipe. Records of such surveys are retained in the research notebook of the

individual doing the work and are locally posted in the area on a monthly basis if any contamination is found.

6. Students use licensed material only under the direct supervision of a laboratory instructor who is a staff member authorized by the University Radiation Safety Committee under the regulations referenced in items 7 and 8 of the application for renewal of SNM 116. Students receive an orientation, outline of which is given in the attached Student Laboratory Orientation Handout. Aside from sealed PuBe sources, the students use only the 12.7 micrograms of SNM in the plated reference sources.

Very truly yours,

R. J. Cashwell
Reactor Director

RJC:mld
Enc. UWNR 100
UWNR 176
UWNR 177
Student Lab. Orientation
Handout

Registered Mail
Return Receipt

SURVEILLANCE ACTIVITIES - See UWNR 100A for details of activities listed and procedure index for techniques of measurements.

1. WEEKLY ACTIVITIES

Week	Date	Initial	Demineralizer Inlet °F	Inlet ph	Inlet Res >.2 MΩ Cm	Outlet ph	Outlet Res > 1 MΩ Cm	Hold Tank Gal * +	Vent System Operable (✓) Emerg	(✓) Room	(✓) BP & TC	Intr Alarm Operable Date/ Initial	GeLi N_2 Added Date/ Initial
1.													
2.													
3.													
4.													
5.													

+ Support liquid waste disposal with completed UWNR 109A Date _____

2. MONTHLY ACTIVITIES

Date	Initial	Item
		Radiation Survey Performed (See Page 4-6)
		Personnel TLD's Changed (Environmental TLD's Quarterly)
		Beam Port Monitors Operable
		HV Monitor Scram and Alarm Operable (Trip and alarm on loss of voltage)
		Pool Level Scram and Alarm Operable (Ext Alarm Jan & July)
		Core Inlet Temp (130°F) (125°F) Scram and Alarm Operable
		Check and/or Clean Filters per 100A List
		Primary H_2O Activity _____ uCi/ml (< 3×10^{-7} - UWNR 100C)
		Secondary H_2O Activity _____ u Ci/ml (< 3×10^{-7} - UWNR 100C)
		If Demineralizer was regenerated, indicate date (UWNR-108)
		12 Intrusion Alarm Switches Operable

3. SEMIANNUAL ACTIVITIES

To be performed May & November or after major maintenance.

SCRAM DELAY TIMES

Date	INITIAL	ELEMENT	ELEC. SCRAM DELAY MSEC (UWNR 168)	RELAY SCRAM RELEASE TIME MSEC (UWNR 167)	TOTAL SCRAM TIME MSEC (RELAY SCRAM)
		Shim 1	(<60 msec)		(< 2 sec)
		Shim 2	(<60 msec)		(< 2 sec)
		Shim 3	(<60 msec)		(< 2 sec)
		Trans			(< 2 sec)

MONTH

(July and January after Power Calibration)

Date_____ Reactor Pulsed to ~1.4% Core Loading_____
Initial_____ Peak Power_____MW Fuel Temp_____°C.
Compare with_____MW and _____°C
previous 6 months or in present core.

4. ANNUAL ACTIVITIES

Initial

_____ January Power Level Calibration completed
UWNR 170 to be inserted in log.

_____ January Air Monitor Calibration completed.
UWNR 171 to be inserted in log.

_____ December Fuel element dimension checks and Visual Inspection;
Inspection of control elements and other underwater components. Report results to RSC.

_____ December Calibrate Fuel Temperature Monitors,
per UWNR 173.

_____ June _____Date

Core Loading_____ Shutdown margin_____
Excess reactivity_____% ΔK/K at core exposure
of _____MW days.

Shutdown margin with most reactive element and reg blade full out_____% (> 0.2% ΔK/K)

Control Element Worths (% ΔK/K)

#1	#2	#3	Reg	Trans
				$\geq$ 1.4% ΔK/K

5. As Required

Date_____ If solid waste was transferred to Univ. Health Physics
Initial_____ Insert completed UWNR 100B form in log.

6. PREVENTATIVE MAINTENANCE SERVICES (Per UWNR 100A)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fission Counter Channel			o						o			
Power Supplies	o						o					
Recorders			o						o			
Log N				o						o		
PA #1					o						o	
PA #2						o						o
Servo	o						o					
Blade Drives 1,2,3		o						o				
Drives-Reg, Trans,FC			o						o			
Lubricate Fans, Motors, Pumps, AC	o			o			o			o		
Area Monitors		o						o				
Air Monitor	o			o			o			o		
HV Monitor					o						o	
Leak Test all Sources, Send Record to U. Health Physicist	o			Pu Only			o			Pu Only		
Intrusion Alarm		o			o			o			o	
Check Logic Element, Trip Actuators					o						o	
Water Process Instruments			o					o				
Health Physics o-Check Instruments Cal-Calibrate			o			o			o			Cal
Emergency Procedures Drill Performed		o								o		
Review Procedures 001-149,° 150-up °° & Submit to RSC for Approval						c					oo	
Continuous Air Monitor		o			o			o			o	

MONTH _____

SWIPE TESTS (100 cm^2 Area--See Page 5 & 6 for location)

Date performed_____ Initial_____

LOCATION	$\mu Ci/100\ cm^2$	LOCATION	$\mu Ci/100\ cm^2$
A		J	
B		K	
C		L	
D		M	
E		N	
F		O	
G		P	
H		Q	

FILTER RADIATION LEVELS & Δ P READINGS WITH FAN RUNNING

Date_____ Initial_____

FILTER	MR/HR	in H_2O (LIMITS)
BP & TC VENT		(.25-2.5)
ROOM EXHAUST		(.25-2.5)
EMERG EXHAUST		
ROOM 132 FUME HOOD		(.25-2.5)
ROOM 43 FUME HOOD		(.25-2.5)

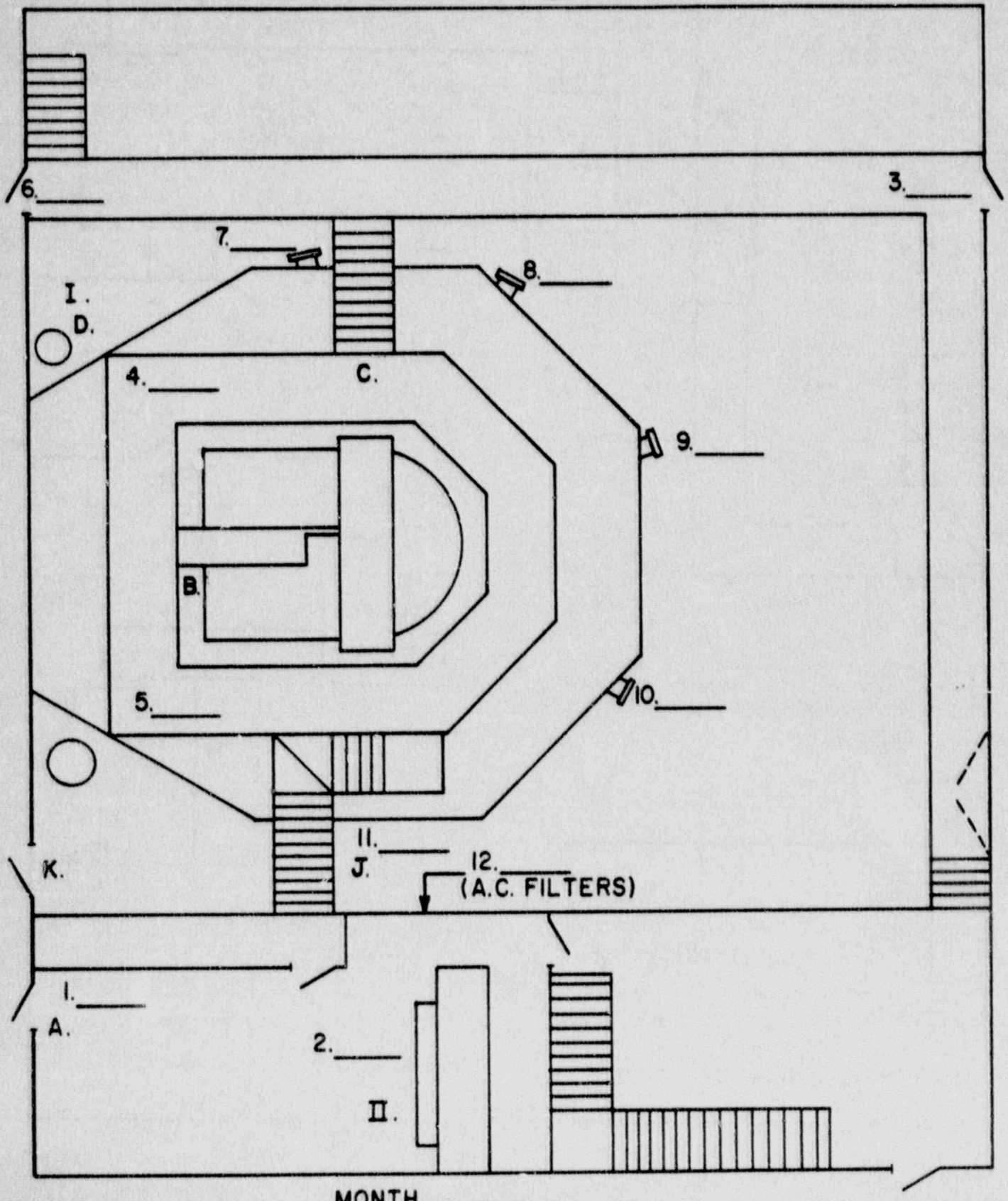
UWNR 100 (5)
REV. 6-10-77

RADIATION LEVELS, AREAS 1. - 22., (mr/hr.)

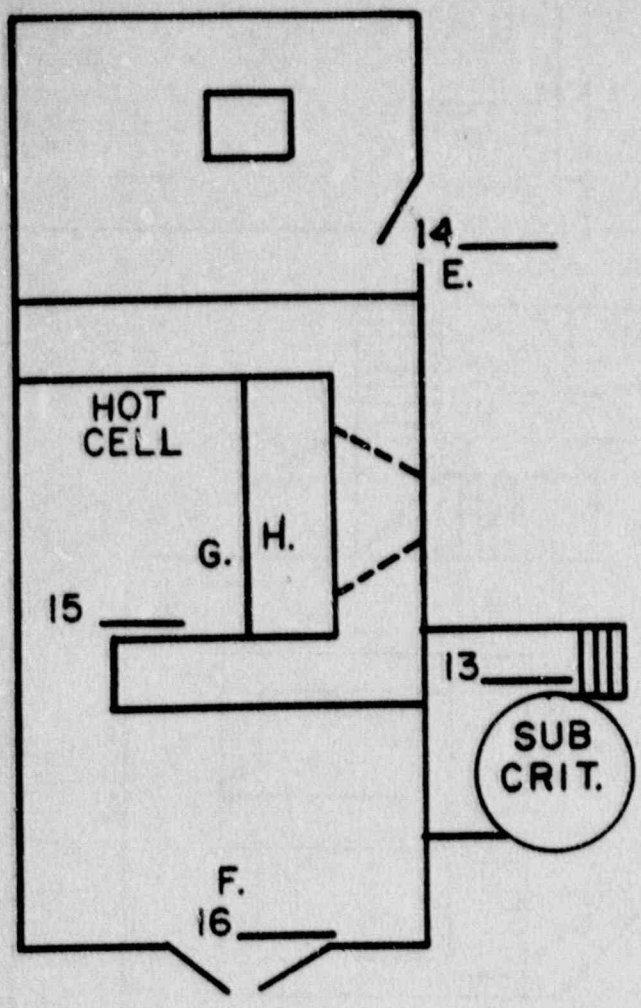
DATE PERFORMED _____
POWER LEVEL _____
INITIAL _____

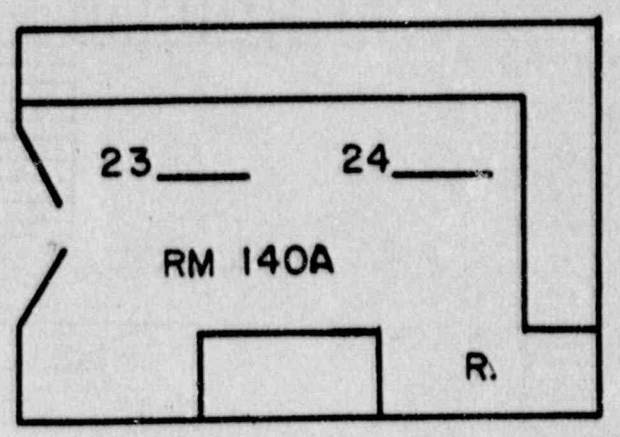
PARTICULATE AIR SAMPLES, (UWNR 172)

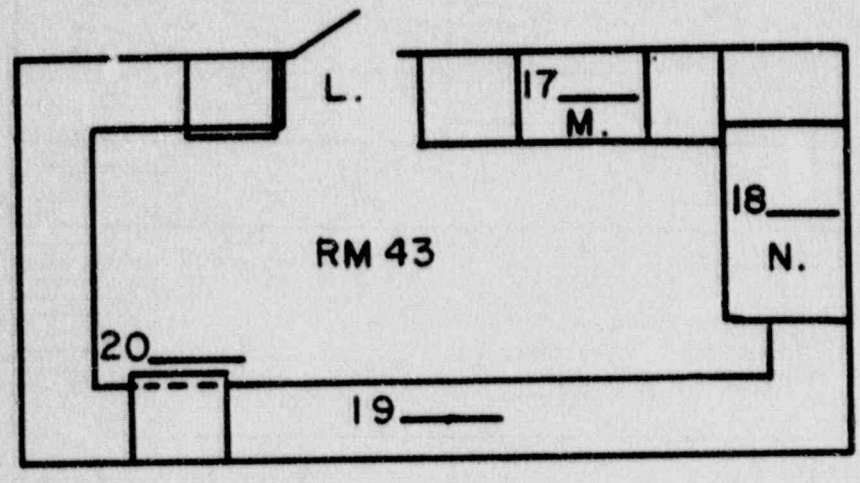
DATE PERFORMED I. _____ II. _____
I. DEMIN. AREA _____ μCi/ml
II. CONSOLE AREA _____ μCi/ml

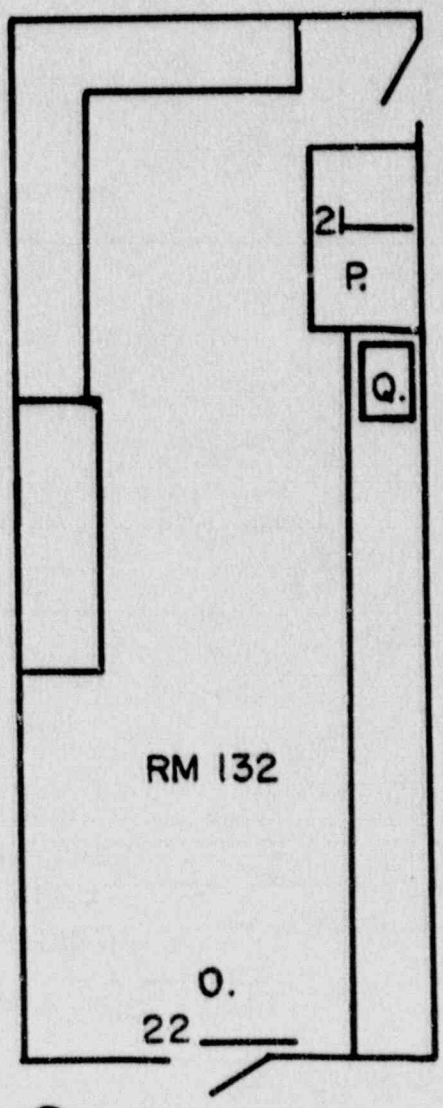


MONTH _____


14
E.
HOT
CELL
G.
H.
15
13
SUB
CRIT.
F.
16


23
24
RM 140A
R.


L.
17
M.
18
N.
RM 43
20
19


21
P.
Q.
RM 132
O.
22

MONTH _____

PROCEDURE FOR USE AND CALIBRATION OF HEALTH PHYSICS INSTRUMENTS

Use of Portable HP Instruments

In addition to the normal steps of battery test and zeroing (where provided on the instrument), the response of the instrument to a standard source must be checked before each use and occasionally during long periods of use.

The detector is placed into the appropriate position on the standard source fixture. The instrument must read within ±20% of the indicated source response.

If the instrument does not meet this requirement, it is to be removed from service by removing the calibration tag and returning it to the electronic shop. If failure to respond to the source was a result of low batteries, the instrument may be restored to service without recalibration if it responds properly to the source after battery replacement. Replacement of any component other than the battery requires a complete recalibration.

Checks and Calibrations

Each instrument in routine use will be checked on a quarterly basis by performing steps 1-6 of the precalibration checks. The instrument will have the entire precalibration and calibration performed on an annual basis.

The scheduled checks and calibration will occur per the schedule contained in UWNR 100, using the attached procedure.

A number of older instruments are retained for special purpose use and demonstrations. These instruments are not to be used for general HP purposes unless they are calibrated according to the manufacturer's instruction book before use.

PRECALIBRATION CHECKS

1. No physical damage.

2. No contamination found with end-window GM instrument.

3. Meter reads zero or minimum on-scale marking when instrument is turned off.

4. One minute warmup time before further checks.

5. Battery check (if any) within designated meter reading and each battery is greater than or equal to nominal battery voltage. For rechargeable battery, instrument battery check indicates o.k. when not plugged into AC power source.

6. Reproducibility checked by exposing detector to same field three times (fixed source to detector distance, turn calibration range on and off). Instrument must read within ±10% of mean reading.

APPENDIX

CALIBRATION METHODS

A. GM Instruments

PRI Model 107C

NOTE: .04 mr/hr range is not calibrated.

	Range	Irradiate with	Adjust	Check within 10% at
1.	.2 mr/hr	0.1 mr/hr	Cal pot	0.15 mr/hr
	2 "	1.0 "	Trimmer 2	0.25,1.5 mr/hr
	20 "	10.0 "	Trimmer 20	2.5, 15 "

2. Affix calibration tag and log in calibration log.

NUCOR CS-30

1. Remove probe. Connect pulse generator through a .01 μfd ≥1000 volt capacitor into detector input. CAUTION: HIGH VOLTAGE PRESENT AT CONNECTOR. Insert negative 0.1 volt pulses and calibrate per table below.

Range	Frequency	Adjust for reading with
X1	300 cpm - 5 Hz	R10
X10	3000 cpm - 50 Hz	R11
X100	30000 cpm - 500 Hz	R12

2. Turn instrument off and connect probe. Irradiate probe with 1 mrem/hr. Attach tag "approximately ____ cpm per mr/hr". Fill in value found in this step.

3. Affix calibration tag and log in calibration log.

EBERLINE RM-14

1. Remove probe. Connect pulse generator through a .01 μfd 1000 volt capacitor into detector insert connector. CAUTION: HIGH VOLTAGE PRESENT AT CONNECTOR. Input a negative 0.1 volt pulse and calibrate as per table below.

Range	Input Frequency	Adjust for reading with
X1	360 cpm - 6 Hz	Calx1
X10	3600 cpm - 60 Hz	Calx10
X100	36000 cpm - 600 Hz	Calx100

2. Turn off and replace detector. Turn on and irradiate probe with 1 mr/hr. Attach tag "approximately ____ cpm per mr/hr γ". Fill in value found in this step.

EBERLINE RM-14 (continued)

3. Affix calibration tag and log in calibration log.

EBERLINE E520

*Note: The x100 range uses the detector built into the case and, thus, that detector must be positioned at the appropriate position when calibrating that range.

1.

Range	Irradiate with	Adjust	Check ±10% at
.01	0.1 mr/hr	.01 Cal	.15 mr/hr
.1	1.0 "	.1 "	0.25,1.5 "
1.0	10.0 "	1.0 "	2.5,15.0 "
10.0	100.0 "	10.0 "	25, 150.0 "
*100.0	250.0 "	100.0 "	--

2. Affix calibration tag and log in calibration log.

B. Ion Chamber Instruments

NOTE: COMPLETE CALIBRATION MAY REQUIRE USE OF HIGH DOSE RATE CALIBRATION RANGE. THE NOTATION (h) IN THE TABLE BELOW INDICATES A DOSE RATE OBTAINED FROM HIGH RANGE.

PIC-6A

CAUTION: HIGH VOLTAGE HAZARD IN NEXT STEP.

1. Connect an electrostatic voltmeter to high voltage output. With instrument in background radiation level and range switch on R/hr range, adjust R18 (high voltage adjust) for an output of 3100 volts.
2. Turn instrument off and disconnect voltmeter. Install meter in special case with cutout for adjusting appropriate range calibration pots.

3.

Scale	Irradiate with	Adjust for reading
mr/hr	1 mr/hr	R10 (mr/hr zero)
	250 mr/hr	R12 (mr/hr span)

If R12 is adjusted, repeat sequence.

4.

R/hr	1 R/hr(h)	R9 (R/hr zero)
	100 R/hr(h)	R11 (R/hr span)

If R11 is adjusted, repeat sequence.

Check response is within 10% at: 1 R/hr(h) on mr/hr range

5. Place back into instrument's own case. Affix calibration tag and log in calibration log.

JUNO

1. Set range switch to "SET". Turn zero control 3/4 revolution from extreme CCW. Adjust internal coarse zero (R13) for zero reading after 1 minute warmup.

NOTE: TWO DIFFERENT FULL SCALE INSTRUMENTS - USE APPROPRIATE TABLE BELOW
NOTE: SET ZERO ON EACH RANGE BEFORE ADJUSTING CALIBRATION

	Range Switch	Irradiate with	Adjust	Check ±10% at
		Full scale = 5		
2.	x1 mr/hr	2.5 mr/hr	x1	1,5 mr/hr
	x10 mr/hr	25 mr/hr	x10	10,50 mr/hr
	x100 mr/hr	250 mr/hr	x100	100 mr/hr
3.	x1 R/hr	2.5 R/hr(h)	x1k	1,5 R/hr
	x10 R/hr	25 R/hr(h)	x10k	10,50 R/hr
		Full scale = 2.5		
2.	x10 mr/hr	25 mr/hr	mr Cal	
3.	x10k mr/hr	25 R/hr(h)	R Cal	
	1 mr/hr	-- --	--	1,2.5 mr/hr
	10 mr/hr	-- --	--	10 mr/hr
	100 mr/hr	-- --	--	100,250 mr/hr
	1 R/hr	-- --	--	1 R/hr(h)
	10 R/hr	-- --	--	10,25 R/hr(h)

4. Affix calibration tag and log in calibration log.

VICTOREEN FALLOUT METER

	Range	Irradiate with	Adjust	Check ±10% at
1.	x1	2.5 R/hr(h)	x1 (R10)	1,5 R/hr(h)
	x10	25 "	x10 (R11)	10,50 "
	x100	250 "	x100(R12)	100 "

2. Affix calibration tag and log in calibration log.
3. Remove batteries; store with meter in emergency kit in room 141.

C. Neutron Survey Meters

SNOOPY (TRACERLAB NP-1)

1. (a) Turn HV set pot R1039 full CCW.
   (b) Place PuBe source near detector.
   (c) Slowly turn R1039 CW until a constant level is indicated.
   (d) Turn R1039 three turns CW to set to optimum point on plateau.
   (e) Remove neutron source and expose to γ calibration range at closest distance to assure no response to γ. If gamma response occurs, reduce HV setting to eliminate (not more than 1 turn on R1039).

SNOOPY (TRACERLAB NP-1) (Continued)

2. Position PuBe source #516 or #517 at distances given in the table below and adjust or check readings as shown in the table. Source and detector must be suspended so that reflection or scatter of neutrons from hydrogenous material is minimuzed.

Range	Source (detector distance (cm))	Adjust or check
20 mrem/hr	50	Adjust cal pot (R1029) for meter reading of 9.1 mrem/hr
200 mrem/hr	30	25.3 mrem/hr ± 10%
2000 mrem/hr	30	25.3 mrem/hr ± 10%
2 mrem/hr	151	1 mrem/hr ± 10%

3. Affix calibration sticker and log in calibration log.

EBERLINE PRM-5 AND BAL'.

Since we have no neutron sources large enough to calibrate the top range, the instrument is calibrated by determining the relationship between counts/minute and mrem/hr using a 1 Ci Pu-Be source and then setting scaler up using a pulse generator.

1. Place detector in highest gamma field available from source range. Increase HV setting until gamma counts begin to indicate; then turn voltage down until gamma counts are just eliminated.
2. Set up a NIM bin with a scaler and a pulser with variable frequency capability. For lower ranges, the pulser will have to be operated with an external frequency generator to get low enough rates.
NOTE: The scaler will count one-half the actual frequency input, but subsequent steps involve using the scaler reading as indicated.
3. Connect the phone output of the meter into the input of the scaler so count rate can be determined when the detector is irradiated with a neutron source. The output is a square wave which will trigger the scaler on either + or - input.
4. Position a 1 Ci Pu-Be source (#516 or #517) 30 cm from the center of the detector ball. Using the scaler, get a statistically significant count of neutron pulse rate (>4000 counts--a 30 minute count is advisable).

Calculate C (CPM/mrem/hr) by

$$C = \frac{\text{Counts}}{(\text{Counting time in minutes})\ (25.3\ \text{mrem(hour})}$$

(C is about 20)

EBERLINE PRM-5 AND BALL (continued)

(a) The model PRM-5 count rate meter has been modified for use as a neutron survey meter. The modification consists of

(1) Changing the meter scaler to indicate mrem/hr instead of CPM.

(2) Shorting the GROSS PHA switch so it always is in GROSS mode.

The digital count rate meter can be made to operate with the detector by switching high voltage power supply boards (P210A). The neutron meter needs the higher voltage supply.

Adjustments:

(b) 5. Turn instrument off, remove from case and remove the high voltage power supply (board P-210A).

6. Set up pulser for a negative 100 milivolt pulse with faster than 1 microsecond rise time and a short fall time. Connect pulser output to instrument input.

7. Determine count rates equivalent to:

8 mrem/hr = 8C
80 mrem/hr = 80C
800 mrem/hr = 800C
8000 mrem/hr = 8000C

8. Turn R2, R3, R4, and R5 full clockwise.

9. With input set per table below, make the indicated adjustments.

Set pulser to (ppm)	Adjust	for Reading of (mrem/hour)
8C	R2	8
80C	R3	80
800C	R4	800
8000C	R5	8000

10. Turn instrument off. Reinstall high voltage power supply and assemble instrument for normal operation.

11. Check for instrument readings with source distances in table below:

Source-Detector Outer Distance(cm)	Reading (mrem/hr)
15	101 ± 10%
30	25.3 ± 10%
50	9.1 ± 10%
100	~2.3

12. Affix calibration sticker and log in calibration log.

INSTRUMENT	SER. NO.	CALIBRATION Low Range DATE	CALIBRATION Low Range INIT	CALIBRATION High Range DATE	CALIBRATION High Range INIT	PRECALIBRATION DATE	PRECALIBRATION INIT	DATE	INIT	DATE	INIT	DATE	INIT
NUCOR CS-30	1004			X	X								
" "	1014			X	X								
PRI	33491			X	X								
"	33492			X	X								
EBERLINE RM-14	2967			X	X								
"	2968			X	X								
"	2978			X	X								
"	2983			X	X								
"	4000			X	X								
EBERLINE E-520	2493			X	X								
" "	2499			X	X								
" "	2505			X	X								
" "	2523			X	X								
EBERLINE PIC-6A	200												
	765												
	783												
	798												
JUNO MODEL 8 II	1027												
" " " "	5035												
" " " "	5037												
VICTOREEN FALLOUT METER (61720)	1670												
TRACERLAB SNOOPY NP1	5019			X	X								
EBERLINE RASCAL PRS2	203			X	X								

NOV 16 1982

RADIOACTIVE SOURCE LEAK CHECK

SPECIAL PRECAUTION: On Pu sources #510 and 511, DO NOT SWIPE THE SOURCE: Swipe the inside of the source holder. Swiping the source will nearly always remove enough material to be detectable. Alpha count all Pu containing source swipes. Count alpha swabs in a windowless counter.

To leak check sources: Thoroughly saturate a cotton swab with alcohol. Wipe entire surface of source with swab. Allow time to dry; count swab; determine activity, and record in the appropriate space on attached sheet. Send completed sheet to the University Health Physicist.

SOURCE	LOCATION	SOURCE ACTIVITY	SWIPE ACTIVITY (μCi)
1. Pu-SRL P-510 (10000 D/M 12/74)	scorce drawer in counting room		
2. Pu-SRL P-511 (10000 D/M 12/74)	scorce drawer in counting room		
3. Pu-Be #928-1 Ci (1.80×10^6n/sec 11/18/60)	reactor pool	2.22×10^6n/sec 11/81	
4. Pu-Be #516-1 Ci (1.83×10^6n/sec 8/23/61)	source barrel	2.12×10^6n/sec 11/81	
5. Pu-Be #517-1 Ci (1.80×10^6n/sec 8/23/61)	source barrel	2.08×10^6n/sec 11/81	
6. Cs^{137} (40 mCi 10/59)	pig in dog-house	24.1 mCi 11/81	
7. Cs^{137} (150 mCi 4/58)	pig in dog-house	87.4 mCi 11/81	
8. Cs^{137} (1 Ci 1/58)	calibration range	529.0 mCi 11/81	
9. Co^{60} (25 mCi 5/15/63)	pig in dog-house	2.2 mCi 11/81	
10. Sr^{90}-30 uC Counting room	in area monitor		
11. Sr^{90}-30 uC Pn Tube	in area monitor		
12. Co^{60} (300 mCi 7/28/65) 3 lifting handles	pig in Rm. 5F	35.2 mCi 11/81	

Signature _____

Date _____

August, 1981

STUDENT LABORATORY ORIENTATION HANDOUT

1. EVACUATION PROCEDURE

The evacuation alarm consists of continuous horns and flashing lights. If you hear the alarm, evacuate immediately to Mechanical Engineering Building Lobby or point more distant from the Reactor Laboratory. Do not take route that will get you closer to the Reactor Laboratory.

Do not re-enter area until given all-clear signal by reactor operation staff member.

2. RADIOACTIVE MATERIAL HANDLING

You will be handling sealed sources, alpha sources, and material irradiated in the reactor.

A. Always wear personnel dosimetry equipment provided on front of body, between waist and neck.

B. Always survey any item other than the small check sources stored in the Counting Laboratories.

C. Do not touch surface of alpha sources or foil surface of beta sources.

D. Always handle irradiation foils with tweezer.

E. Any sample irradiated in the reactor must be assumed to be contaminated.

Always (1) Wear gloves,
(2) Wash hands afterwards,
(3) Survey hands and report to lab instructor or reactor staff if contamination is found.

F. Never place radioactive material in regular trash cans. Specially marked stainless steel cans are available for radioactive waste disposal. ALWAYS consult instructor before disposing of radioactive material.

G. No smoking, eating, or drinking in any areas where radioactive material is stored or used.

H. You should wash hands before leaving laboratory areas. Leave personnel dosimeters in racks provided.

I. Although the Nuclear Engineering Department has made extensive efforts to prevent your exposure to hazardous materials, radiation safety precautions are stressed as part of your training.

J. Special instructions regarding radiation exposure to females are contained in Regulatory Guide 8.13. Ask your instructor for a copy of this guide to read.

K. Radiation exposure records are posted on the Reactor Laboratory bulletin board and you may obtain information on your radiation exposure upon request.

3. SECURITY

A. All areas containing radioactive material must be locked if not occupied by persons familiar with radiation safety.

B. The Reactor Laboratory is a highly restricted area. You must be accompanied by your instructor or reactor staff to remain in the area. DO NOT BLOCK OPEN DOOR OR ATTEMPT TO DEFEAT LOCKS.

C. Do not attempt to operate or adjust equipment except on laboratory set-ups under direction of laboratory instructor or reactor operating staff.

D. Always report any condition you feel is potentially unsafe to your instructor or the Reactor Supervisor.

E. Refer any questions on radiation safety to instructor or laboratory staff.