CUA

THE CATHOLIC UNIVERSITY OF AMERICA

Environmental Health and Safety
Washington, DC 20064
202-319-5500
Fax 202-319-4446

Br. 2

June 3, 2013

License Nos. SNM-164; SUD-157; 08-02075-03

Docket Nos. 07-00190, 040-06329, 030-00638

United States Nuclear Regulatory Commission-Region I
2100 Renaissance Blvd. Suite 100
King of Prussia, PA 19406-2713

Subject: Request for License Renewal SUD-157 04006329

The Radiation Safety Committee (RSC) has requested from the Radiation Safety Officer to submit a request of renewal application for license number SUD-157 which is set to expire on 07/31/2013.

We are hereby submitting the application request of renewal. Please note that a part of the application is the CUA Radiation Safety Manual which has been updated in order to accurately reflect our management control program and radiation safety procedures.

If you have any questions or need further information, please contact me at 202-319-5500 and email conradj@cua.edu or the Radiation Safety Officer, Mr. Mahmoud S. Haleem at 202-319-5206 and email Haleem@cua.edu . Thank you in advance for your time.

Sincerely,

Mr. Jerry Conrad
Associate Vice President for Facilities Operations

Cc: Mr. Louis P. Alar, Director, Environmental Health & Safety
Mr. Mahmoud S. Haleem, Radiation Safety Officer
Dr. Aaron Barkatt, Chair, Radiation Safety Committee

Enclosures

1. NRC license renewal application form 313.
2. 5 pages of answered items #5-11 of NRC Form 313
3. Radiation Safety Manual
4. Diagram of the laboratories where the requested licensed materials will be handled.
5. Curriculum Vitae for Dr. Aaron Barkatt, Chair, Radiation Safety Committee
6. Curriculum Vitae for Mr. Mahmoud Haleem, Radiation Safety Officer
7. Printout of Power Point presentation of the radiation safety training.

NRC FORM 313 (03-2013) 10 CFR 30, 32, 33, 34, 35, 36, 39, and 40

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR MATERIALS LICENSE

APPROVED BY OMB: NO. 3150-0120 **EXPIRES: 05/31/2015**

Estimated burden per response to comply with this mandatory collection request: 4.3 hours. Submittal of the application is necessary to determine that the applicant is qualified and that adequate procedures exist to protect the public health and safety. Send comments regarding burden estimate to the Information Services Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to Infocollects.Resource@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0120), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

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. *AMENDMENTS/RENEWALS THAT INCREASE THE SCOPE OF THE EXISTING LICENSE TO A NEW OR HIGHER FEE CATEGORY WILL REQUIRE A FEE.

APPLICATION FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

OFFICE OF FEDERAL & STATE MATERIALS AND
ENVIRONMENTAL MANAGEMENT PROGRAMS
DIVISION OF MATERIALS SAFETY AND STATE AGREEMENTS
U.S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS:

IF YOU ARE LOCATED IN:

ALABAMA, CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, FLORIDA, GEORGIA, KENTUCKY, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, NORTH CAROLINA, PENNSYLVANIA, PUERTO RICO, RHODE ISLAND, SOUTH CAROLINA, TENNESSEE, VERMONT, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA,

SEND APPLICATIONS TO:

LICENSING ASSISTANCE TEAM
DIVISION OF NUCLEAR MATERIALS SAFETY
U.S. NUCLEAR REGULATORY COMMISSION, REGION I
2100 RENAISSANCE BOULEVARD, SUITE 100
KING OF PRUSSIA, PA 19406-2713

IF YOU ARE LOCATED IN:

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

MATERIALS LICENSING BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION III
2443 WARRENVILLE ROAD, SUITE 210
LISLE, IL 60532-4352

ALASKA, ARIZONA, ARKANSAS, CALIFORNIA, COLORADO, HAWAII, IDAHO, KANSAS, LOUISIANA, MISSISSIPPI, MONTANA, NEBRASKA, NEVADA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, OREGON, PACIFIC TRUST TERRITORIES, SOUTH DAKOTA, TEXAS, UTAH, WASHINGTON, OR WYOMING,

SEND APPLICATIONS TO:

NUCLEAR MATERIALS LICENSING BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
1600 E. LAMAR BOULEVARD
ARLINGTON, TX 76011-4511

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 JURISDICTIONS.

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

- [ ] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER
- [x] C. RENEWAL OF LICENSE NUMBER SUD-157

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include ZIP code)*

The catholic University of America
Department of Environmental Health & Safety
Radiation Safety Officer
620 Michigan Ave, N.E. Washington, D.C. 20064

3. ADDRESS WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

The Catholic University of America
620 Michigan Ave. N.E.
Washington D.C. 20064

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

Mahmoud Haleem

BUSINESS TELEPHONE NUMBER	BUSINESS CELLULAR TELEPHONE NUMBER
(202) 319-5206	(202) 446-4350

BUSINESS EMAIL ADDRESS

HALEEM@CUA.EDU

SUBMIT ITEMS 5 THROUGH 11 ON 8-1/2 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. maiximum 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 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 (Fees required only for new applications, with few exceptions*) *(See 10 CFR 170 and Section 170.31)*

FEE CATEGORY: Exempt AMOUNT ENCLOSED $

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 , 36, 39, AND 40, AND THAT ALL INFORMATION CONTANED 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 C RIMINAL 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.

CERTIFYING OFFICER -- TYPED/PRINTED NAME AND TITLE	SIGNATURE	DATE
Jerry Conrad, Associate Vice President for Facilities Operations	[signature]	6-5-13

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	AMOUNT RECEIVED	CHECK NUMBER	COMMENTS
			$		
APPROVED BY				DATE	

Item No. 5 RADIOACTIVE MATERIAL

- **For unsealed materials**

Source Material	Chemical and/or Physical Form	Maximum requested possession limit
A. Natural Uranium	Any	10 kilograms
B. Depleted Uranium	Any	10 kilograms
C. Natural Thorium	Any	50 kilograms
D. Thorium 232	Any	50 kilograms

Item No. 6 PURPOSE FOR WHICH LICENSED MATERIAL WILL BE USED

SUD items A, B, C, and D will be specifically used for research and development to demonstrate vitrification methods applicable to the long term storage of radioactive materials. Chemically, there are no good substitutes for these source materials. They have been and will continue to be used to study the physical and chemical properties associated with long term storage.

ITEM No. 7 INDIVIDUAL(S) REPSONSIBLE FOR RADIATION SAFETY PROGRAM

The **Radiation Safety Officer (RSO)** for this license is Mahmoud S. Haleem. Mr. Haleem was appointed as the RSO on the license via amendment 1. A copy of his resume is attached to this application.

The Chair of the University's Radiation Safety Committee (RSC) continues to be Dr. Aaron Barkatt. Dr. Barkatt was named to the materials license via amendment 13. A copy of his curriculum vitae is attached. Additional RSC members include the RSO, Director, Environmental Health & Safety, at least one representative from Maintenance and Operations, and a faculty member qualified by training and experience in the use of radioactive materials or radiation producing equipment from each Department/Laboratory extensively using sources of ionizing radiation.

Authorized Users (AUs) are individuals who may work unsupervised with licensed materials as well as supervise individual users approved to work with licensed materials. A proposed AU must first complete an application describing the proposed research involving radioactive materials and establishing the individual's experience with radioactivity. The application is submitted to the RSO for review and comment preceding presentation to the RSC for additional evaluation and ultimate approval.

The RSO will maintain files on all AUs; records will document the method by which the individual meets the criteria established for working as an AU under the license.

ITEM No. 8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS

The Catholic University of America (CUA) maintains broad scope byproduct and SNM licenses as well as this SUD license. Education and training for radiation safety is addressed in section 9.2.12 of the Radiation Safety Manual. These pages are attached to this application. CUA conducts specific training classes for basic and refresher radiation safety training for all persons who are designated users of radioactive materials or radiation producing machines. Such persons are named on the approved AU application to work with radioactive materials. CUA training classes are customized for basic training, refresher training when it is needed in response to changes in experimental procedure, and training concerning prenatal radiation exposure, as well as communicating the relevant regulatory information established in 10 CFR Part 19. Project-specific training may also be conducted on an as needed basis. The effectiveness of training is assessed by a test following basic and refresher training. Examples of class curricula are attached.

All personnel visiting or frequenting any portion of the restricted areas will receive instructions concerning the hazards of the area, appropriate responses to warning, and their responsibility to report violations. The extent of this instruction shall be commensurate with potential radiation hazards in the restricted area(s).

ITEM No. 9. FACILITIES AND EQUIPMENT

Work under this license is conducted in Hannan Hall, which was designed and built for the purpose of conducting work with radioactive materials. It has been in operation since 1987. The south wing of the basement floor is isolated by locked corridors, and designated as controlled/restricted area to accommodate virtrification studies on radioactive materials. Ventilation is "once through". Make-up and exhaust air are balanced to maintain the wing at negative pressure with respect to the rest of the basement. Fume hoods are provided with automatic air velocity control and low-flow alarms. There are no windows in the wing. There is a single key controlled entrance and an additional 'emergency exit only' at the opposite end of the corridor.

This SUD license continues to support CUA research on the treatability of radioactive materials at government storage sites through vitrification. Small quantities of the resulting glass samples are then analyzed and evaluated for the physical and chemical properties necessary for possible long-term storage of materials at the originating site.

All uranium in use consists of depleted uranium; it is all stored in room 39 (see attached diagram). The uranium is kept in a glove box where it is weighed and added to a combination of various glass formers. After weighing and homogenizing, the mixture is placed in one of three furnaces, each equipped with an exhaust and HEPA filters, and melted at approximately 1200°C. Once vitrification is completed, the glass containing the uranium is collected and processed for analysis. The preparation of the glass samples for characterization takes place in the glove box. Following preparation, the resulting aliquot, with a typical activity of trace amounts to a few tenths of a microcurie, is distributed to various labs for analysis. The labs are listed below and their description can be found in the attachments provided.

- Room 39 – The glass is re-melted and analyzed for viscosity and electrical conductivity.
- Room 38A – The glass is cut and polished in preparation of examination by electron microscopy. A glove box provides the necessary containment.
- Room 39 – The glass is re-melted and heat treated.
- Room 40 – The glass samples are archived after analysis.
- Room 230 – The glass is analyzed for composition by X-ray Fluorescence (XRF) and Mössbauer spectroscopies.
- Room 232 – The glass is analyzed by X-ray Diffraction (XRD).
- Room 236 – The glass is dissolved by microwave-assisted and acid dissolution.
- Room 331 – The glass dissolved in Room 236 is analyzed by Ion Chromatography (IC), Direct Coupled Plasma (DCP), and Atomic Absorption (AA).
- Room 335 – The glass is tested for leaching resistance using the Product Consistency Testing (PCT).
- Room 336 – The glass is prepared and analyzed for leaching resistance using the Toxicity Characteristic Leaching Procedure (TCLP).
- Rooms 102 and 434 – The glass is examined by electron microscopy.

The custody of each aliquot is tracked through a comprehensive chain of custody system. Each of the above laboratories is equipped with state of the art engineering controls.

Radioactive materials will be used in rooms posted with "Caution Radioactive Materials" signs. Access to these areas will be limited to persons authorized to work with licensed materials. The RSO will approve all areas in which radioactive materials are used or stored. Floor diagrams and a description of the uranium storage and use areas area attached; they identify the areas that will be posted for radioactive materials.

Prior to allowing work with radioactive materials to proceed in any area, the RSO shall inspect the area and verify that:

- Radiation detection equipment is available,
- Shielding, if necessary, is available,
- Remote handling equipment is available, if necessary,

- Personnel have access to personal protective equipment, such as gloves, lab coats, protective eyewear, etc.,

- Bench tops are equipped with materials, such as absorbent paper, spill trays, or other appropriate items, to prevent the spread of radioactive contamination,

- Radioactive waste containers are available and present,

- Proper signs are posted,

- Security measures are in place to assure the security of radioactive materials in storage, and

- Other requirements are met as necessary.

If applicable, cabinets or other storage compartments with lead or plastic (e.g., Lucite) shields are used in some locations to store radioactive sources. Sources are locked in a room, or, if the room is not locked, within locked refrigerators, freezers, or other storage cabinets or closets when not in use to prevent theft or unauthorized access.

CUA has an extensive inventory of hand-held radiation detection instrumentation. These include Ludlum Model 3 meters with pancake GM probes and NaI detectors, alpha scintillation detectors, and numerous exposure rate instruments including ion chambers, pressurized ion chambers, and plastic scintillators. We also possess liquid scintillation counters. We reserve the right to replace any of the equipment with other makes and models of radiation detectors/analytical instruments as needed. Portable radiation survey meters used for required radiation safety surveys are calibrated at least annually. CUA commits to an NRC or Agreement state licensed facility authorized to perform instrument calibrations. The RSO will maintain copies of all records of instrument calibration. In all cases, we shall use instruments that meet the radiation monitoring instrument specifications published in NUREG-1556.

ITEM No. 10. <u>RADIATION SAFETY PROGRAM</u>

See Radiation Safety Manual (attached).

ITEM No. 11. <u>WASTE MANAGEMENT</u>

CUA ensures that the disposal of all licensed special nuclear material waste is in accordance with the requirements of 10 CFR Part 20 Subpart K. The university maintains a building dedicated exclusively to interim storage of radioactive waste generated from any licensed activity conducted under our SNM, SUD, and byproduct materials licenses. The building is heated, secured, equipped with alarms monitored by the campus public safety/security department, and is under the control of the Environmental Health & Safety Department.

As necessary and while available, CUA reserves the right to transfer radioactive waste to a licensed radioactive waste broker for off-site disposal. Any CUA employees involved in shipping radioactive wastes have to complete required radioactive materials shipping training, as specified in U.S. Department of Transportation regulations in 49 CFR 172, Subpart H.

2001-2005 **University of Maryland-College Park**
Department of Environmental Safety/ Radiation Safety Office
College Park, MD 20742
Position: Health Physicist

Responsibilities:

Duties included teaching and training researchers, undergraduate and graduate students in the principles of the Physics of Radiation Protection and proper safe use of radioactive materials and X-ray machines. Conducting laboratory radiation and environmental surveys and audits, management of dosimetry program, maintaining inventory and control records, assisted departments and laboratories in complying with radiation and environmental safety rules and regulations, receiving and shipping radioactive materials, training researchers and graduate students in the proper safe use of radioactive materials and X-ray machines. Inspected, audited research laboratories for industrial hygiene, fire safety, occupational safety, radiation safety, biological safety and environmental affairs utilizing laboratory safety survey Checklist.

2001-2001 **Department of Defense/ Air Force Medical Operation Agency/ SGZR**
110 Luke Avenue, Room 405
Bolling AFB, DC 20332-7050
Position: Health Physicist Intern

Responsibilities:

Duties included issuing, renewing, amending and terminating permits for radioactive materials use throughout the Air Force, and Air Force Reserve under the authority of the Nuclear Regulatory Commission issued Master Material License. Responsibilities also included investigating discrepancies and violations for permitted and non-permitted radioactive materials, also providing environmental and occupational health physics consultant assistance to USAF installations worldwide.

1993- 2000 **King Fahd University of Petroleum & Minerals**
Research Institute/ Energy Research Laboratory, Dhahran, Saudi Arabia
Position: Lecturer

Responsibilities:

Participated in the development and teaching of the laboratory section and classes for the short course titled "Radiation Protection Principles". Responsibilities included training local nationals at the Research Center in performing radiation survey and sampling as needed. Duties involved sampling and measuring the tritium level of the effluent release through the stack.

Duties included the carrying out and operation of radioactive sources inventory, leak test of sealed sources, and instrument calibrations of the interlock system. Duties entailed safety inspections of labs, external and internal (bioassay) dosimetry program including maintenance of dosimetry and bioassay records, project review for regulatory compliance, radiation safety training, and updating and developing operational health physics procedures.

1990- 1993 **Brookhaven National Laboratory**
Associated Universities, Inc.
Environmental Safety and Protection Division
Upton, NY 11973
Position: Project Safety Engineer

Responsibilities:

Acted as safety and environmental protection representative to Physics and Chemistry Departments on behalf of Safety Division. Responsibilities included performing safety audits and reviewing experimental and shop activities. These included health physics, industrial hygiene, environmental, hazardous waste and safety engineering reviews. Advised and assisted the Physics and Chemistry

Departments on compliance with DOE orders and OSHA requirements. Responsibilities also entailed reviewing and approving radiation work permits and supervising three technicians who were responsible for radiation monitoring in Physics, and Chemistry labs which also included monitoring experimental runs and maintenance in the cyclotron facility. Duties also included overseeing radiation monitoring of radiation workers during the administration of short-lived isotopes to patients in the PET facility, and reviewing and writing safety instructions for industrial hygiene/safety concerns.

1985-1990 **The Catholic University of America, Radiation Safety Office**
Washington, D.C. 20064
Position: Health Physicist-I

Responsibilities:
Assisted the Radiation Safety officer in the operation of the radiation protection program by conducting environmental radiation surveys utilizing radiation detectors and counters. Duties also included calibrating of radiation survey instruments, maintaining inventory and control records, assisted departments and laboratories in complying with radiation safety rules and regulations, receiving and shipping radioactive materials, distributing and collecting the monthly film badge dosimeters, and other responsibilities as may be assigned by the Radiation Safety officer.

Membership:
Plenary member of the Health Physics Society (HPS) since 1989.

REFERENCES:
Furnished upon request.

MAHMOUD S. HALEEM
[redacted]
Telephone numbers: (H) 301-946-9091
(W) 202-319-5206
E-mail: haleem@cua.edu

SUMMARY

Radiation Safety Officer-Health Physicist with more than twenty five years experience in the field of radiation safety and associated broad scope by-product, source, and special nuclear material licensing activities in an academic research oriented universities. Extensive experience in laboratory management, decontamination and decommissioning, auditing and training. Excellent verbal and written skills on technical subjects. Demonstrated success managing project teams in the preparation of licenses, environmental reports, permit applications and manuals.

Education:

Georgetown University
Washington D.C. 20057
Master degree in Physics of Radiation Science with a major in Health Physics

University of Massachusetts
Boston, MA 02125
College of Arts and Sciences, Bachelor of Science in Chemistry.

EMPLOYMENT HIGHLIGHTS:

2005-Present

The Catholic University of America
Environmental Health & Safety
Radiation Safety office, Marist Annex
Washington, D.C. 20064
Position: Radiation Safety Officer

Responsibilities:

Responsible for the execution of a comprehensive, university wide radiation safety program to implement all technical and regulatory compliance aspects associated with broad scope byproduct, source, and special nuclear material licenses. This includes administration of the technical and regulatory compliance aspects of the radiation safety program; regularly verifying implementation of radiation safety policies; consulting with faculty and staff; reviewing formal applications to use radioactive material and radiation producing machines; conducting radiation safety training; overseeing the radiation safety program and the dosimetry program; implementing and performing the radioactive waste processing and storage program. I am responsible for investigation of any radiation safety incident or "close call" and advise the principle investigator and the radiation safety committee of findings and recommendations. Also, I am involved in providing effective professional guidance and safety training for the research laboratory staff and facilities support personnel.

CURRICULUM VITAE

Dr. Aaron Barkatt

Department of Chemistry
201 Maloney Hall
The Catholic University of America
Washington, DC 20064
Phone: (202) 319-5397
FAX: (202) 319-5381
e-mail: barkatt@cua.edu

Education:

Ph.D. [redacted] Chemistry (Physical), The Hebrew University of Jerusalem, Israel.
Thesis: Radiation Chemistry of Glasses.
Advisors: Dr. J. Rabani and Dr. M. Ottolenghi.

M.Sc. [redacted] Chemistry (Physical and Applied), The Hebrew University of Jerusalem, Israel; with distinction.
Thesis: Photochemical Decomposition of Nitrogen Trichloride.
Advisor: Dr. H. Feilchenfeld.

B.Sc. [redacted] Chemistry and Physics, The Hebrew University of Jerusalem, Israel.
(1 year of undergraduate studies at the University of Oslo, Norway).

Employment Summary:

September, 1976 to present:
The Catholic University of America (CUA), Washington, DC 20064.
Present position: Professor, Department of Chemistry, and Director of Oxide Chemistry Group, and Research Associate, Vitreous State Laboratory

May, 2008 to present:
Adjunct professor, Department of Materials Science and Engineering, University of Maryland, College Park, MD 20742

December, 1986 to March, 1989:
Senior Staff Scientist, Duratek Corporation, Greenbelt, MD 20770.

April, 1980 to December, 1986:
Principal Investigator and Group Manager, NPD Nuclear Systems, Inc., New York, NY 10022.

September, 1974 to September, 1976:
Research Associate, Department of Chemistry, Purdue University, West Lafayette, IN 47907.

September, 1969 to September, 1974:
Research Assistant, later Instructor, Department of Physical Chemistry, The Hebrew University of Jerusalem, Israel.

Experience:

At The Catholic University of America, has worked as a project manager directing a group of post-doctoral research associates, graduate students and technicians involved in the following projects: (i) Mechanisms of the interaction between glass and aqueous environments; (ii) inorganic ion-exchangers; (iii) fiber optic biomedical sensors of blood chemistry. Initiated and set up projects involving (iv) glasses with surface properties or optical properties suitable for solar applications; (v) novel chromatographic materials for high-pH separations; (vi) interactions of glass with natural environments; (vii) synthesis and chemical properties of oxide high-temperature superconductors; (viii) hydrothermal evolution of iron oxides and characterization of steam generator sludge; (ix) synthesis and characterization of rare-earth phosphate gels, colloids and glasses; (x) characteristics of natural glasses; (xi) glass transitions in organic liquids; (xii) synthesis and characterization of iron phosphates; (xiii) environmental degradation of fiber-reinforced plastics; (xiv) evolution of subsurface water upon exposure to heat; (xv) reactions of nickel and titanium alloys with geochemical environments; (xvi) reactions of glassy and ceramic materials with cementitious environments; (xvii) thermal evolution of compositions of subsurface water; (xvii) geopolymers; (xviii) cenospheres in fly ash; (xix) magnesium-based cemetitious materials; (xx) dissolved metal contaminants and nano-particles in drinking water sources and distribution systems; (xxi) environmental effects of aluminum in natural streams; (xxii) crystal habit modifiers for oxide deposits; (xxiii) kinetics of reactions of solvents with oxide deposits; (xiv) strengthening of IR-transmitting glasses; (xxv) magnetic properties of bismuth-tellurium-iron compounds; (xxvi) polymerization of acrylate and formation of ionomers; (xxvii) reactions of low-level waste glasses in disposal environments

Areas of Specialization and Techniques:

Spectroscopy (UV, visible, IR, AA), kinetic measurements, glass preparation, irradiation (steady-state and pulsed), radiochemical techniques and counting, photochemistry (steady-state, laser, flash), relaxation methods (T-jump), thermal analysis (DSC, DTA, TGA), separation techniques (GC, HPLC, ion chromatography, ion-exchange, adsorption, solvent extraction), e.s.r., n.m.r., atomic absorption and plasma spectrometry, electrokinetic potentials, x-ray diffractometry (XRD), freeze-drying, data processing.

Technical Contributions:

Approximately 110 papers in scientific journals and 12 patents, numerous talks and presentations. Visiting Scientist, Argonne National Laboratory, 1976; Member of Steering Committee, Leaching Mechanisms Program, organized by Pacific Northwest Laboratory under contract to the U.S. Department of Energy, 1981-1984. Member of Editorial Advisory Board of Nuclear Technology (an American Nuclear Society publication), 1985-1995. Member of the U.S. Department of Energy

Salt Repository Project Program Peer Panel Review Committee, 1986-1988. Chair, Symposium on Materials Stability and Environmental Degradation, Materials Research Society, April 1988, and editor of volume of proceedings. President, Washington-Baltimore Section of the Materials Research Society, 1989-1990. Member of Member of Committee C-26 on Nuclear Fuel Cycle, ASTM (American Society for Testing and Materials), 1988-1991. Publications Committee, Materials Research Society, 1991-1992. Member of Steering Group, High-Level Waste Borosilicate Glass: A Compendium of Corrosion Characteristics, US Department of Energy, Office of Waste Management, 1992-1994. Chair, Symposium on Scientific Basis for Nuclear Waste Management, Materials Research Society, November - December 1993, and editor of volume of proceedings. Secretary, Committee T-3M on Chemical Cleaning and Task Force on Deposit Characterization, National Association of Corrosion Engineers, 1995 - 1996. Vice-Chair, Committee T-3M, 1996 - 1997. Chair, Committee T-3M, 1997 - 1999. Vice-Chair, Baltimore-Washington Section, National Association of Corrosion Engineers, 2005 - 2006. Member, International Expert Panel on Yucca Mountain, 2003 – present. Member, Member of Infrastructure Expert Team, Oak Ridge Associated Universities/US Department of Homeland Security, 2004 - 2008. Reviewer, US Department of Energy NEUP (Nuclear Energy University Program, 2011.

Teaching Experience:

At CUA:

CHEM 563 Advanced Physical Chemistry (1978)
ME 514 Ceramic Engineering (1979)
CHE 506 Special Topics in Chemical Engineering (1980)
CHEM 531 Chemical Thermodynamics and Molecular Dynamics (1982)
CHEM 531 Chemical Thermodynamics and Molecular Dynamics (1986)
CHEM 766 Research Topics in Chemistry (1987)
CHEM 531 Chemical Thermodynamics and Molecular Dynamics (1987)
CHEM 508 Instrumental Analysis and Chemical Spectroscopy (1988)
CHEM 351 Physical Chemistry (1988)
CHEM 731 Advanced Topics in Physical and Inorganic Chemistry (1988)
CHEM 352 Physical Chemistry (1989)
CHEM 732 Advanced Topics in Physical and Inorganic Chemistry (1989)
CHEM 766 Research Topics in Chemistry (1989)
CHEM 768 Research Problems in Chemistry (1989)
CHEM 311 Analytical Chemistry (1989) (Lecture)
CHEM 500 Searching the Chemical Literarure (1989)
BIOL 577 Research Problems in Biology (1989)
CHEM 767 Research Problems in Chemistry (1989)
CHEM 530 Thermodynamics (1990) (1st half - Chemical Thermodynamics)
CHEM 540 Chemistry of Materials (1990) (Spring)
CHEM 492 Undergraduate Research (1990)
BIOL 578 Research Problems in Biology (1990)
CHEM 768 Research Problems in Chemistry (1990)
CHEM 351/551 Physical Chemistry (1990)
CHEM 540 Chemistry of Materials (1990) (Fall)
CHEM 593 Current Trends in Chemistry (1990)
CHEM 597 Intermediate Research (1990)

CHEM 767 Research Problems in Chemistry (1990)
CHEM 352/552 Physical Chemistry (1991)
CHEM 508 Instrumental Analysis and Chemical Spectroscopy (1991)
CHEM 594 Current Trends in Chemistry (1991)
CHEM 598 Intermediate Research (1991)
CHEM 351/551 Physical Chemistry (1991)
CHEM 540 Chemistry of Materials (1991)
CHEM 491 Undergraduate Research (1991)
CHEM 593 Current Trends in Chemistry (1991)
CHEM 597 Intermediate Research (1991)
CHEM 352/552 Physical Chemistry (1992)
CHEM 508/550 Instrumental Analysis and Chemical Spectroscopy (1992)
CHEM 594 Current Trends in Chemistry (1992)
CHEM 598 Intermediate Research (1992)
CHEM 351/551 Physical Chemistry (1992)
CHEM 491 Undergraduate Research (1992)
CHEM 540 Chemistry of Materials (1992)
CHEM 765 Research Topics in Chemistry (1992)
CHEM 767 Research Problems in Chemistry (1992)
CHEM 352/552 Physical Chemistry (1993)
CHEM 508/550 Instrumental Analysis and Chemical Spectroscopy (1993)
CHEM 766 Research Topics in Chemistry (1993)
CHEM 768 Research Problems in Chemistry (1993)
CE 542 Environmental Chemistry Laboratory (1993)
CHEM 491 Undergraduate Research (1993)
CHEM 597 Intermediate Research (1993)
CHEM 765 Research Topics in Chemistry (1993)
CHEM 108 General Chemistry (1994)
CHEM 492 Undergraduate Research (1994)
CHEM 598 Intermediate Research (1994)
CHEM 311 Analytical Chemistry (1994)
CE 542 Environmental Chemistry Laboratory (1994)
CHEM 491 Undergraduate Research (1994)
CHEM 597 Intermediate Research (1994)
CHEM 767 Research Problems in Chemistry (1994)
CHEM 108 General Chemistry (1995)
CHEM 492 Undergraduate Research (1995)
CHEM 508/550 Instrumental Analysis and Chemical Spectroscopy (1995)
CHEM 354 Physical Chemistry Laboratory - Partial (1995)
CE 542 Environmental Chemistry Laboratory (1995)
HSEV 101 Environmental Science and Engineering - one-third (1995)
CHEM 491 Undergraduate Research (1995)
CHEM 108 General Chemistry (1996)
CHEM 508/550 Instrumental Analysis and Chemical Spectroscopy (1996)
CHEM 492 Undergraduate Research (1996)
CHEM 594 Current Trends in Chemistry (1996)

CHEM 500 Technical Writing and Information Retrieval (1996)
CHEM 765 Research Topics in Chemistry (1996)
CHEM 767 Research Problems in Chemistry (1996)
HSEV 101 Environmental Science and Engineering - one-third (1996)
BIOL 317 Principles of Environmental Science - one-half (1996)
CHEM 108 General Chemistry (1997)
CHEM 508/550 Instrumental Analysis and Chemical Spectroscopy (1997)
CHEM 311 Analytical Chemistry (1997)
CHEM 103 General Chemistry - Problem/Quiz (1997)
CE 542 Environmental Chemistry Laboratory (1997)
ENGR 395 Engineering Materials (1997)
HSEV 101 Environmental Science and Engineering - one-half (1997)
BIOL 317 Principles of Environmental Science - one-half (1997)
CHEM 491 Undergraduate Research (1997)
CHEM 765 Research Topics in Chemistry (1997)
CHEM 108 General Chemistry (1998)
CHEM 508/550 Instrumental Analysis and Chemical Spectroscopy (1998)
CHEM 492 Undergraduate Research (1998)
CHEM 770 Research Topics (1998)
CHEM 103 General Chemistry (1998)
ENGR 395 Engineering Materials (1998)
HSEV 101 Environmental Science and Engineering - one-half (1998)
BIOL 317 Principles of Environmental Science - one-half (1998)
CHEM 597 Intermediate Research (1998)
CHEM 765 Research Topics in Chemistry (1998)
CHEM 108 General Chemistry (1999)
CE 102 Geology and Hydrology - two-thirds (1999)
CHEM 598 Intermediate Research (1999)
CHEM 766 Research Topics in Chemistry (1999)
CHEM 311 Analytical Chemistry (1999)
CHEM 317/BIOL 317 Principles of Environmental Science (1999)
CHEM 395 Materials Science and Engineering (1999)
CHEM 542 Environmental Chemistry Laboratory (1999)
CHEM 103 General Chemistry - Problem/Quiz - one-half (1999)
CHEM 593 Current Trends in Chemistry (1999)
CHEM 108 General Chemistry (2000)
CE 102 Introduction to Earth Science - two-thirds (2000)
CHEM 508 Instrumental Methods of Analysis - one-half (2000)
CHEM 318 Environmental Science Seminar (2000)
CHEM 768 Research Problems in Chemistry (2000)
CHEM 491 Undergraduate Research (2000)
CHEM 492 Undergraduate Research (2000)
CHEM 311 Analytical Chemistry (2000)
CHEM 317 Principles of Environmental Science (2000)
CHEM 395 Materials Science and Engineering (2000)
CHEM 542 Environmental Chemistry Laboratory (2000)

HSEV 101 Environmental Science and Engineering – one-half (2000)
CHEM 500 Technical Writing and Information Retrieval – one-fifth (2000)
CHEM 108 General Chemistry (2001)
CE 102 Introduction to Earth Science - one-half (2001)
CHEM 318 Environmental Science Seminar (2001)
ENGR 538 Introduction to Environmental Engineering - one-half (2001)
CHEM 395 Materials Science and Engineering (2001)
ENGR 538 Introduction to Environmental Engineering (2002)
CE 102 Introduction to Earth Science - one-half (2002)
CHEM 508 Instrumental Analysis and Chemical Spectroscopy - one-half (2002)
CHEM 518 Chemical Instrumentation Laboratory - one-quarter (2002)
CHEM 395 Materials Science and Engineering (2002)
HSEV 101 Environmental Science and Engineering - one-half (2002)
CHEM 491 Undergraduate Research (2002)
CHEM 317 Principles of Environmental Science (2003)
CHEM 318 Seminar in Environmental Science (2003)
CHEM 538 Introduction to Environmental Engineering (2003)
CHEM 113 General Chemistry Laboratory I (2003)
HSEV 101 Environmental Science and Engineering - one-quarter (2003)
CHEM 114 General Chemistry Laboratory II (2004)
CHEM 113 General Chemistry Laboratory I (2004)
CHEM 395 Materials Science and Engineering (2004)
CHEM 317 Principles of Environmental Science (2005)
CHEM 318 Seminar in Environmental Science (2005)
CHEM 107 General Chemistry (2005)
CHEM 395 Materials Science and Engineering (2005)
CHEM 108 General Chemistry (2006)
CHEM 538 Introduction to Environmental Engineering (2006)
CHEM 317 Principles of Environmental Science (2006)
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CHEM 108 General Chemistry (2007)
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CHEM 538 Introduction to Environmental Engineering (2007)
CHEM 317 Principles of Environmental Science (2007)
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CHEM 108 General Chemistry (2008)
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CHEM 318 Seminar in Environmental Science (2009)
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CHEM 395 Materials Science and Engineering (2009)
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CHEM 318 Seminar in Environmental Science (2010)
CHEM 538 Introduction to Environmental Engineering (2010)
HSEV 101 Environmental Science and Engineering (2010)
CHEM 317 Principles of Environmental Science (2010)
CHEM 395 Materials Science and Engineering (2010)
CHEM 103 General Chemistry I (2011)
CHEM 107 General Chemistry I (2011)
CHEM 113 General Chemistry Laboratory (2011)
CHEM 318 Seminar in Environmental Science (2011)
HSEV 101 Environmental Science and Engineering (2011)
CHEM 317 Principles of Environmental Science (2011)
CHEM 395 Materials Science and Engineering (2011)
CHEM 103 General Chemistry I (2012)
CHEM 107 General Chemistry I (2012)
CHEM 113 General Chemistry Laboratory (2012)
CHEM 318 Seminar in Environmental Science (2012)
HSEV 101 Environmental Science and Engineering (2012)
CHEM 317 Principles of Environmental Science (2012)
CHEM 395 Materials Science and Engineering (2012)
CHEM 540 Chemistry of Materials (2012)

Alpha Delta Gamma Instructor of the Month, October 1995
Faculty Advisor, Green (Environmental) Club, 1998 - 2002

Dissertation Guidance:

9 Ph.D. dissertations; 7 Master's dissertations; 14 senior projects

1. Warren E. Keene, "Development and Demonstration of a System for Vitrifying High Level Radioactive Waste in High Silica Glass", Ph. D., School of Engineering and Architecture, 1987.

2. Xiangdong Feng, "Composition Effects on Chemical Durability and Viscosity of Nuclear Waste Glasses - Systematic Studies and Structural Thermodynamic Models", Ph. D., School of Arts and Sciences, 1988.

3. Robert F. Jakubik, "Surface Chemistry of Glasses: Sorption, Ion Exchange and Durability", Ph. D., School of Arts and Sciences, 1991.

4. Yan Guo, "Sol-Gel Synthesis and Characteristics of the Rare Earth Phosphate Glasses", Ph. D., School of Arts and Sciences, 1993.

5. Jing C. Sang, "Chemistry of Glass dissolution: Kinetics, Mechanism, and Surface Reactions", Ph. D., School of Arts and Sciences, 1994.

6. Marta U. Gmurczyk, "Investigation of Degradable Decontamination Solvents for Contaminated Metal Surfaces", Ph. D., School of Arts and Sciences, 1996.

7. Ewa Labuda, "Reactions of Iron Oxides at Elevated Pressures and Temperatures", Ph. D., School of Arts and Sciences, 1996.

8. Luca Prian, "Envirinmental Degradation of Fiber Reinforced Plastics", Ph.D., School of Arts and Sciences, 1998.

9. Zhijian Feng, "The Oxidation of Metallic Copper: Kinetics, Mechanism, and Product Characteristics", 2002.

Thesis Reader:

1. Elie E. Saad, "Physical Properties of Multicomponent Borosilicate Glasses: A Study of Viscosity, Processing and Durability", Ph. D., School of Arts and Sciences, 1988.

2. Meiling Gong, "Studies in Atomic Ionization and Reactions of Molecules and Radicals", Ph. D., School of Arts and Sciences, 1991.

3. Shouxiang Hu, "High-Temperature, High-Current-Density Superconductors: Preparation, Structure, Superconducting Properties, and Flux-Pinning Mechanisms", Ph. D., School of Arts and Sciences, 1991.

4. Jocelyn Y. Buckley, "Metal Distribution in the Phases Formed by Protonation and Deprotonation of Sewage Sludge", M. E., School of Arts and Sciences, Howard University, 1992.

5. Yan Feng, "Kinetics and Mechanism of the Oxidative Coupling of Methane over 1% Sr/La_2O_3", Ph. D., School of Arts and Sciences, 1993.

6. Mary Ann Perozzo, "X-ray Crystallographic Structure Analysis of *Aequorea victoria* Green Fluorescent Protein", Ph.D., School of Arts and Sciences, 1997.

7. Charles D. Merritt, "Photo- and Electro-Luminescence of Guest Molecules in Organic matrices", Ph.D., School of Arts and Sciences, 1998.

8. Ming Li, "Investigation of Dislocation Instability and Jog Motion via Molecular Dynamics", Ph.D., School of Arts and Sciences, 1999.

9. Stanislav I. Stoliarov, "Experimental and Theoretical Studies of the Reaction between Vinyl and Methyl Radicals in the Gas Phase", Ph.D., School of Arts and Sciences, 1999.

10. Charles Ewers, "Reclaiming the Farmer Paradigm: A Strategy for Environmental Rhetoric", Ph.D., School of Arts and Sciences, 2003.

11. Sr. Damien Marie Savino, "Urban River Restoration: The Confluence between Restoration of

People and Restoration of Place in light of Holling's Creative Destruction Dynamic and Bonaventure's Concept of Mediation", School of Engineering, 2005.

12. Francis Emmanuel T. Mensah, "Use of the SOLEX System with the 248-nm KrF and the 355-nm Nd:YAG Lasers for the Calibration of Lidar Systems for Water Vapor Determination", Howard University, Department of Physics and Astronomy, 2007

13. Alia P. Weaver, "Ionizing Radiation-Induced Copolymerization of 2-Ethylhexyl Acrylate and Acrylic Acid and Ionomer Formation", University of Maryland, Department of Materials Science and Engineering, 2007.

14. Joon H. Yang, "The Attachment and Characterization of DNA Probes on GaAs-based Semiconductor Surfaces", University of Maryland, Department of Materials Science and Engineering, 2007.

Master's Degree Guidance:

1. Peter Lin, School of Engineering and Architecture, 1979.
2. Yan Guo, School of Arts and Sciences, 1990.
3. Marta Wozniak, School of Arts and Sciences, 1991.
4. Ewa Labuda, School of Arts and Sciences, 1992.
5. Jing C. Sang, School of Arts and Sciences, 1992.
6. Luca Prian, School of Arts and Sciences, 1996.
7. Xueliang Wang, School of Arts and Sciences, 1996.
8. Zhijian Feng, School of Arts and Sciences, 1998.

Senior Comprehensive Guidance:

1. Mary Manning, 1990
2. James Carrick, 1992
3. April Pulvirenti, 1993
4. Thomas Tullio, 1994
5. Mark Ladolcetta, 1994
6. Donna Wilder, 1995
7. Anne Vieira, 1999
8. Christina L. Monkres, 2001
9. Elizabeth Bishop, 2003
10. Ingeborg Iping-Petterson, 2004
11. Katherine Jenko, 2006
12. Sarah Clemente, 2009
13. Erin McNulty, 2009
14. Matthew O'Reilly, 2010

List of Publications--Aaron Barkatt

Refereed Articles:

1. Aa. Barkatt, M. Ottolenghi and J. Rabani, "Pulse Radiolysis of Sodium Metaphosphate Glasses", J. Phys. Chem., 76, 203-213 (1972).

2. Aa. Barkatt and J. Ogdan, "Pulse Irradiation of Diamonds", J. Phys. Chem. Solids, 33, 2217-2227 (1972).

3. Aa. Barkatt, M. Ottolenghi and J. Rabani, "Spur Recombination and Diffusion Processes in Pulse Irradiated Inorganic Glasses", J. Phys. Chem., 77, 2857-2863 (1973).

4. Y. Kobayashi, Aa. Barkatt and J. Rabani, "Yields of Radiation Products in Sodium Metaphosphate Glasses", J. Phys. Chem., 78, 752-756 (1973).

5. Aa. Barkatt and M. Ottolenghi, "Laser Flash Photolysis of Aqueous Tri-iodide Solutions", Mol. Photochem., 6, 253-261 (1974).

6. Aa. Barkatt and Y. Kobayashi, "Pulse Radiolytic Investigation of Iodoplatinates. Application in the Determination of Platinum in Metaphosphate Glasses", Anal. Chem., 47, 178-179 (1975).

7. Aa. Barkatt and J. Rabani, "Metal Precipitation from Pulse Irradiated Solutions of Cd^{2+} and Similar Cations", J. Phys. Chem., 79, 1359-1362 (1975).

8. Aa. Barkatt and C. A. Angell, "On the Use of Structual Probe Ions for Relaxation Studies in Glasses I. Spectroscopic Properties of Cobalt (II) in Chloride-Doped Potassium Nitrate-Calcium Nitrate Glasses", J. Phys. Chem., 79, 2192-2197 (1975).

9. Aa. Barkatt and J. Rabani, "Kinetics of Spur Reactions of Electrons in Ethylene Glycol-Water Glassy Ice, a Pulse Radiolytic Study", J. Phys. Chem., 79, 2592-2597 (1975).

10. C. A. Angell, A. Barkatt, C. T. Moynihan and H. Sasabe, "Kinetics of Structural Relaxation in the Glass Transformation Range of a Calcium-Potassium Nitrate Melt by Probe Ion Spectroscopy", Proc. Int. Symp. Molten Salts, ed. J. Pemsler et al., The Electrochemical Society, Princeton, NJ, 1976, pp. 195-203.

11. Aa. Barkatt and C. A. Angell, "The Charge Transfer to Solvent Spectrum of Iodide in Supercooled Water and Glass-Forming Aqueous Solutions", J. Phys. Chem., 81, 114-120 (1977).

12. Aa. Barkatt, Y. Kobayashi, and J. Rabani, "Absorption Spectra of Radiation Products (Cd^+, Pb^+, $I^{2-)}$ in Sodium Metaphosphate Glass", Rad. Effec., 36, 245-247 (1978).

13. Aa. Barkatt and C. A. Angell, "Use of Structural Probe Ions for Relaxation Studies in Glasses. 2. Temperature-Jump and Temperature-Ramp Studies of Cobalt (II) in Nitrate Glasses", J. Phys. Chem., 82, 1972-1979 (1978).

14. Aa. Barkatt, C. A. Angell, and J. R. Miller, "Radiation Products and Tunneling Processes in

Ionic Glasses. 1. Radiation Products and Recombination in Undoped Nitrate and Acetate Glasses", J. Phys. Chem., 82, 2143-2148 (1978).

15. Aa. Barkatt and C. A. Angell, "Optical Probe Studies of Relaxation Processes in Viscous Liquids", J. Chem. Phys., 70, 901-911 (1979).

16. J. H. Simmons, P. B. Macedo, Aa. Barkatt and T. A. Litovitz, "Fixation of Radioactive Wastes in High Silica Glasses", Nature (London), 278, 729-731 (1979).

17. H. N. Bhargava, P. K. Agarwal and Aa. Barkatt, "Glass Transition Temperatures of Copolyphosphates", Coll. Poly. Sci., 257, 1172-1179 (1979).

18. Aa. Barkatt, C. A. Angell and J. R. Miller, "Visible Spectroscopy of Irradiated High-Alkali Borate and Mixed Alkali Phosphate Glasses", J. Am. Ceram. Soc., 64, 158-162 (1981).

19. Aa. Barkatt, J. H. Simmons, and P. B. Macedo, "Corrosion Mechanisms and Chemical Durability of Radioactive Waste Glasses", Nucl. Chem. Waste Management, 2, 3-23 (1981).

20. Aa. Barkatt and C. J. Simmons, "Near-IR Vibrational Spectrum of Hydroxyl Groups as a Structural Probe in Oxide Glasses", J. Phys. Chem., 85, 1824-1834 (1981).

21. Aa. Barkatt, J. H. Simmons, and P. B. Macedo, "Evaluation of Chemical Stability of Vitrification Media for Radioactive Waste Products", Phys. Chem. Glasses, 22, 73-85 (1981).

22. Aa. Barkatt, Al. Barkatt, P. E. Pehrsson, P. Szoke and P. B. Macedo, "Static and Dynamic Tests for the Chemical Durability of Nuclear Waste Glass", Nucl. Chem. Waste Management, 2, 151-164 (1981).

23. Aa. Barkatt, Al. Barkatt, P. E. Pehrsson, P. B. Macedo and J. H. Simmons, "The Importance of CO_2 Buffering and of the Total Ionic Balance in Measurements on the Durability of Glasses", Nucl. Tech., 56, 271-277 (1982).

24. J. H. Simmons, Aa. Barkatt, and P. B. Macedo, "Mechanisms Which Control Aqueous Leaching of Nuclear Waste Glass", Nucl. Tech., 56, 265-270 (1982).

25. P. B. Macedo, Aa. Barkatt and J. H. Simmons, "A Flow Model for the Kinetics of Dissolution of Nuclear Waste Glasses", Nucl. Chem. Waste Management, 3, 13-21 (1982).

26. Aa. Barkatt, Al. Barkatt and W. Sousanpour, "Effects of Gamma-Radiation on the Leaching Kinetics of Various Nuclear Waste-form Materials", Nature (London), 300, 339-341 (1982).

27. P. B. Macedo, Aa. Barkatt and J. H. Simmons, "A Flow Model for the Kinetics of Dissolution of Nuclear Waste Forms: A Comparison of Borosilicate Glass, Synroc and High-Silica Glass", Scientific Basis for Nuclear Waste Management, Vol. V, ed. W. Lutze, North-Holland, New York, 1982, pp. 57-69.

28. Aa. Barkatt, Al. Barkatt and W. Sousanpour, "Gamma Radiolysis of Aqueous Media and Its Effects on Leaching Processes of Nuclear Waste-forms", Nucl. Tech., 60, 218-227 (1983).

29. Aa. Barkatt, P. B. Macedo, W. Sousanpour, Al. Barkatt, M.-A. Boroomand, P. Szoke and V. L. Rogers, "Correlation between Dynamic Leach Test Results and Geological Observations", Scientific Basis for Nuclear Waste Management, Vol. VI, ed. D. G. Brookins, North-Holland, New York, 1983, pp. 227-234.

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36. Aa. Barkatt, W. Sousanpour, Al. Barkatt and M.-A. Boroomand, "Effects of Metals and Metal Oxides on the Leaching of Nuclear Waste Glasses", Scientific Basis for Nuclear Waste Management, Vol. VII, ed. G. L. McVay, North-Holland, N.Y., 1984, pp. 689-696.

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39. Aa. Barkatt, P. B. Macedo, L. M. Penafiel, W. Sousanpour and H. G. Sutter, "Removal of Radioactive Cesium from Streams with a High Potassium Content", Trans. Amer. Nucl. Soc., 46,

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43. P. B. Macedo, B. C. Gibson, Aa. Barkatt and C. J. Montrose, "Long Term Release Rates of Borosilicate Glass Waste Forms", Nucl. Tech., 73, 199-209 (1986).

44. X. Feng and Aa. Barkatt, "Solubility Tests on Borosilicate Glasses for West Valley Waste Immobilization", Trans. Amer. Nucl. Soc., 53, 133-134 (1986).

45. R. Adiga, Aa. Barkatt and D. E. Clark, "Leach Behavior of Defense Waste Glass under Static and Dynamic Conditions", Nuclear Waste Management II, Advances in Ceramics Vol. 20, eds. D. E. Clark, W. B. White and A. J. Machiels, The American Ceramic Society, Columbus, Ohio, 1986, pp. 487-494.

46. Aa. Barkatt, E. E. Saad, R. Adiga, W. Sousanpour, Al. Barkatt and S. Alterescu, "Leaching of Microtektite Glass Compositions in Seawater", Nuclear Waste Management II, Advances in Ceramics Vol. 20, eds. D. E. Clark, W. B. White and A. J. Machiels, The American Ceramic Society, Columbus, Ohio, 1986, pp. 681-687.

47. X. Feng and Aa. Barkatt, "Effects of Aqueous Phase Composition on the Leach Behavior of Nuclear Waste Glasses", Scientific Basis for Nuclear Waste Management, Vol. X, eds. J. K. Bates and W. B. Seefeldt, Materials Research Society, Pittsburgh, PA, 1987, pp. 519-531.

48. X. Feng and Aa. Barkatt, "Structural Thermodynamic Model for the Durability and Viscosity of Nuclear Waste Glasses", Scientific Basis for Nuclear Waste Management, Vol. XI, eds. M. J. Apted and R. E. Westerman, Materials Research Society, Pittsburgh, PA, 1987, pp. 543-554.

49. X. Feng, Aa. Barkatt and T. Jiang, "Systematic Composition Studies on the Durability of Waste Glass WV205", Scientific Basis for Nuclear Waste Management, Vol. XI, eds. M. J. Apted and R. E. Westerman, Materials Research Society, Pittsburgh, PA, 1987, pp. 673-683.

50. Aa. Barkatt, K. A. Michael, H. Hojaji and H. G. Sutter, "Treatment of Various Nuclear Generating Station Waste Waters with Durasil Media" in Recent Progress in Adsorption and Ion Exchange, eds. Y. H. Ma and J. P Ausikaitis, AIChE Symp. Ser. no. 259, Vol. 83, American Institute of Chemical Engineers, New York, NY, 1987, pp. 73-79.

51. Aa. Barkatt, K. A. Michael, W. Sousanpour, Al. Barkatt, L. M. Penafiel, P. B. Macedo and H. G. Sutter, "Properties of Novel Selective Ion Exchangers for Nuclear Plant Applications", Nucl. Tech., 78, 75-82 (1987).

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53. Aa. Barkatt, H. Hojaji and K. A. Michael, "Reactions of Barium-Yttrium-Copper Oxides with Aqueous Media and their Applications in Structural Characterization", Advanced Ceramic Materials, 2, 701-709 (1987).

54. Aa. Barkatt, E. E. Saad, R. B. Adiga, W. Sousanpour, Al. Barkatt, X. Feng, J. A. O'Keefe and S. Alterescu, "Interactions of Silicate Glasses with Aqueous Environments under Conditions of Prolonged Contact and Flow", Materials Stability and Environmental Degradation, eds. Aa. Barkatt, E. D. Verink, Jr. and L. R. Smith, Materials Research Society, Pittsburgh, PA, 1988, pp. 129-142.

55. Aa. Barkatt, H. Hojaji and K. A. Michael, "Characterization of Oxidized Species in Superconducting Ternary Oxides by Solution Chemistry", Mat. Res. Bull., 23, 735-742 (1988).

56. H. Hojaji, Aa. Barkatt and R. A. Hein, "Preparation and Properties of Highly Densified Yttrium-Barium-Copper Oxide", Mat. Res. Bull., 23, 869-879 (1988).

57. H. Hojaji, K. A. Michael, Aa. Barkatt, A. N. Thorpe, M. F. Ware, I. G. Talmy, D. A. Haught and S. Alterescu, "A Comparative Study of Sintered and Melt-Grown Recrystallized $YBa_2Cu_3O_x$", J. Mater. Res., 4, 28-32 (1989).

58. X. Feng, I. L. Pegg, Aa. Barkatt, P. B. Macedo, S. J. Cucinell and S. Lai, "Correlation Between Composition Effects on Glass Durability and the Structural Role of the Constituent Oxides", Nucl. Tech., 85, 334-345 (1989).

59. R. A. Hein, H. Hojaji, Aa. Barkatt, H. Shafii, K. A. Michael, A. N. Thorpe, M. F. Ware and S. Alterescu, "The Low Magnetic Field Properties of Superconducting Bulk Yttrium Barium Copper Oxide - Sintered versus Partially Melted Material", J. Superconductivity, 2, 427-461 (1989).

60. Aa. Barkatt, E. E. Saad, R. Adiga, W. Sousanpour, Al. Barkatt, M. A. Adel-Hadadi, J. A. O'Keefe and S. Alterescu, "Leaching of Natural and Nuclear Waste Glasses in Sea Water", Appl. Geochem., 4, 593-603 (1989).

61. R. E. Sassoon, M. Gong, M. Brandys, M. A. Adel-Hadadi, Aa. Barkatt and P. B. Macedo, "Analaysis of Brine Leachates from MIIT. 1. Leaching of Nuclear Waste Glass Doped with Chemical Tracers", Nuclear Waste Management IV, Advances in Ceramics, The American Ceramic Society, Columbus, Ohio, 1990.

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Waste Glass", Nuclear Waste Management IV, Advances in Ceramics, The American Ceramic Society, Columbus, Ohio, 1990.

63. X. Feng, I. L. Pegg, E. E. Saad, S. Cucinell and Aa. Barkatt, "Redox Effects on the Durability and Viscosity of Nuclear Waste Glasses", Nuclear Waste Management IV, Advances in Ceramics, The American Ceramic Society, Columbus, Ohio, 1990.

64. X. Feng, I. L. Pegg, Aa. Barkatt and P. B. Macedo, "Effects of Surface-Area-to-Solution Volume on the Chemical Durability of Nuclear Waste Glasses", Scientific Basis for Nuclear Waste Management, Vol. XIII, eds. V. M. Oversby and P. W. Brown, Materials Research Society, Pittsburgh, PA, 1990, pp. 383-392.

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67. H. Hojaji, Aa. Barkatt, S. Hu, K. A. Michael, A. N. Thorpe, I. G. Talmy, D. A. Haught and S. Alterescu, "Elemental Fractionation and Magnetic Properties of Melt-Based $Y_1Ba_2Cu_3O_z$ Containing Excess Tb or Pt", Mat. Res. Bull., 25, 1025-1033 (1990).

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57. M. Al-Sheikhly, A. Barkatt and J. Silverman, "Radiation-Chemical Treatment of Plant Materials for the Production of Biofuels", Proceedings of IRaP 2010, the 9th Meeting of the Ionizing Radiation and Polymers Symposium, October 25-29, 2010, College Park, Maryland

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A.L. Pulvirenti, M.A. Adel-Hadadi, A. Barkatt, C. Marks, J.A. Gorman and R.W. Staehle, "Continuing Investigations of Local Environments on Waste Container Surfaces", The Board on Radioactive Waste Management, National Academy of Science, Washington, DC, December 12, 2002

M. Al-Sheikhly, A. Barkatt* and J. Silverman, "Radiation-Chemical Treatment of Plant Materials for the Production of Biofuels", IRaP 2010, the 9th Meeting of the Ionizing Radiation and Polymers Symposium, October 25-29, 2010, College Park, Maryland (*Invited speaker)

Patents:

1. Aa. Barkatt and P. B. Macedo, "Silica Removal Process and Alumina Composition Used Therein", U.S. Patent 4,332,031, May 25, 1982.

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7. Aa. Barkatt, "Supported Heteropolycyclic Compounds in the Separation and Removal of Late Transition Metals", U. S. Patent 4,876,232, October 24, 1989.

8. Aa. Barkatt, "Supported Heteropolycyclic Compounds in the Separation and Removal of Late Transition Metals", U. S. Patent 4,995,984, February 26, 1991.

9. H. Hojaji and Aa. Barkatt, "Method for the Formation of High Temperature Superconductors", U. S. Patent 5,270,292, December 14, 1993.

10. Aa. Barkatt and S.A. Olszowka, "Removal of Radioactive or Heavy Metal Contaminants by Means of Non-Persistent Complexing Agents", U. S. Patent 5,434,331, July 18, 1995.

11. Aa. Barkatt, E. Labuda, M. Gmurczyk and Donna M. Wilder, "Immobilization of Radioactive and Hazardous Contaminants and Protection of Surfaces against Corrosion by means of Ferric Oxides", U.S. Patent 6,084,146, July 4, 2000.

12. M. Lemus, Aa. Barkatt, M. Gmurczyk and G. Cherepakhov,"Thermal Treatment and Immobilization Processes for Organic Materials", U.S. Patent 6,288,300, September 11, 2001.

Departmental Committees:

Equipment Committee, 1988-1989, 1993-1994; 1994-1995 (Chair)
Library Committee, 1989-1990, 1990-1991, 1991-1992
Graduate Curriculum Committee, 1989-1990, 1990-1991, 1991-1992
Undergraduate Curriculum Committee 1991-1992, 1992-1993, 1993-1994 (Chair); 1994-1995
Undergraduate Recruitment Committee, 1993-1994, 1994-1995
Department Secretary, 2002 – 2003; 2004-2007

Secretary, Examination Committee, Final Ph. D. Examinations:

Kevin Truong, School of Arts and Sciences (1990)
Gary Wood, School of Arts and Sciences (1991)
John Ward, School of Music (1992)
Thomas M. McGuire, School of Arts and Sciences (1993)
Enjie Wang, School of Arts and Sciences (1994)
Mark Quigley, School of Arts and Sciences (1996)

Chair, Examination Committee, Final Ph. D. Examinations:

Xiang Mao, School of Arts and Sciences (1998)
Senjian Annamalei, School of Arts and Sciences (2007)
Shylaja M. Hedge, School of Arts and Sciences (2009)
Jane Cox, School of Nursing (2010)
David Fernandez, School of Arts and Sciences (2012)

Reviewer, Doctoral Proposals:

Nicholas R. Collins, School of Arts and Sciences (2003)
Edward J. Wassell III, School of Arts and Sciences (2003)
Yuangsheng Mei, School of Engineering (2004)
Steve Wissing, School of Arts and Sciences (2007)

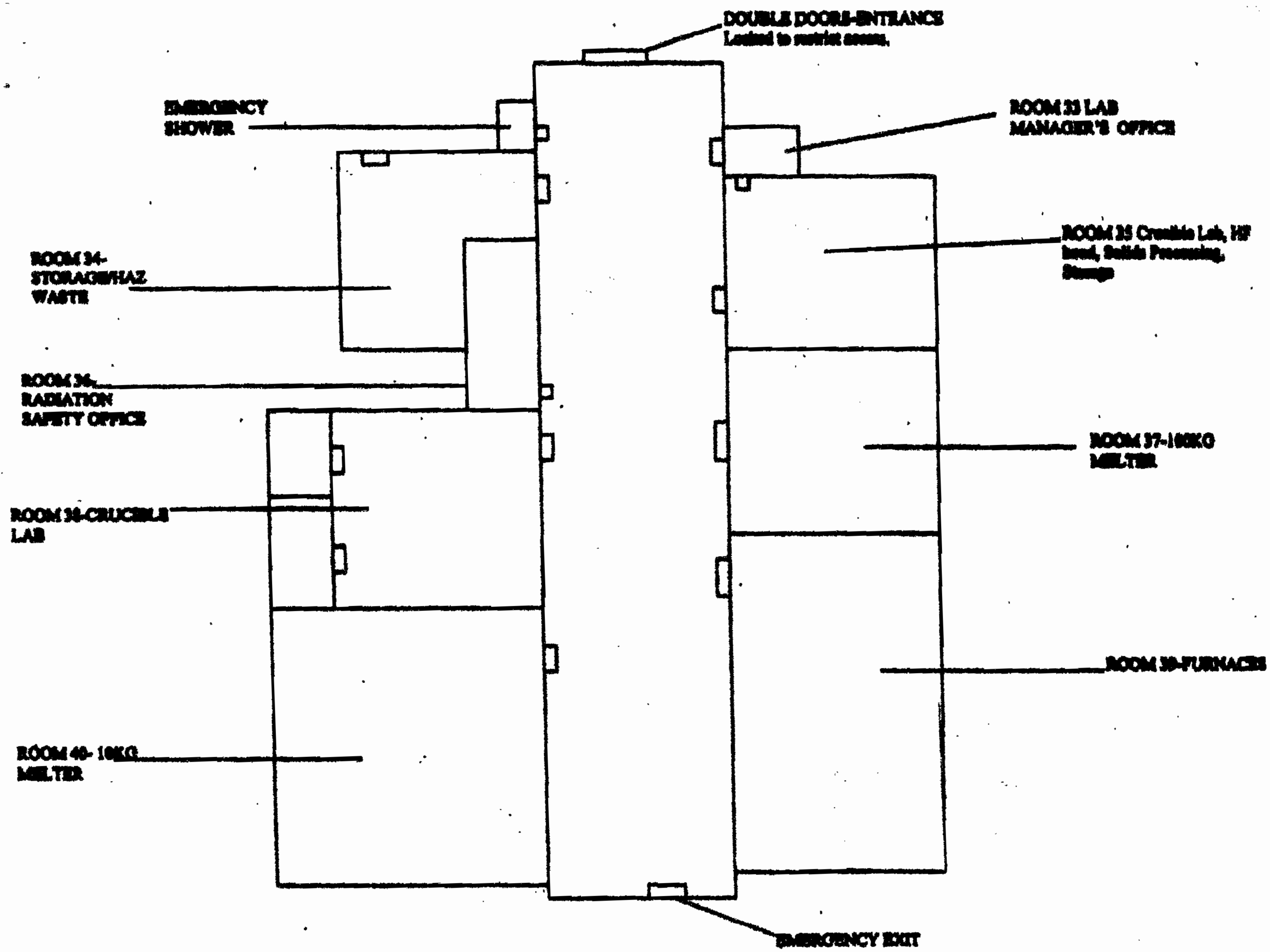
Other University Activities:

Consultant to Search Committee for CUA Director of Environmental Safety, 1989
Organizer of superconductivity session, College Focus program, School of Arts and Sciences, 1990 and 1991.
Mentor, Center for Excellence in Education, 1991
Institute of Chemical Education, lecture on superconductivity, 1992
Graduate Board, 1992 - 1998
Radiation Safety Committee: Member, 1993 - 1996;
Chair, 1996 - Present
Reader's Program for Incoming Freshmen, 1995 – 2006.
Faculty Marshal, Commencement Exercises, 1992, 1993, 1994, 1999.
Task Force on Environmental Studies Program: Chair, 1997.
Committee on Appointments and Promotions, School of Arts and Sciences, 1998 – 2001.

Member, Comparative Perspectives Subcommittee, Self-Study for the Middle States Accreditation, 1998 - 1999.
Director, Environmental Chemistry Program, 1998 – 2002.
Member, Patent Committee, 1999 - Present
Member, Committee on Faculty Economic Welfare, 2005 - 2010.
Member, Advisory Board for the Materials Science and Engineering MS Program, 2010 - Present

Location of Work with Depleted Uranium

or Thorium and Associated Glasses

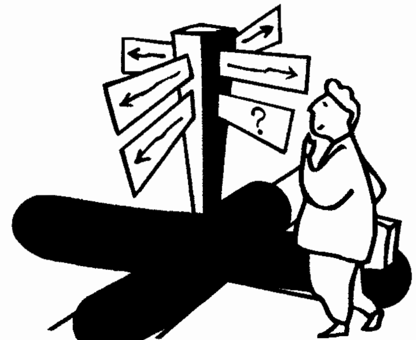


Radioactive Materials Safety Training

The Catholic University of America
Radiation Protection Program
Mahmoud Haleem
Haleem@cua.edu
x5206

Outline

1. Introduction
2. Radiation Physics
3. Units and Quantities
4. Background and Occupational Radiation Doses
5. Biological Effects of Ionizing Radiation
6. Minimizing Radiation Exposures - **ALARA**
7. General Radiation Safety and Surveys



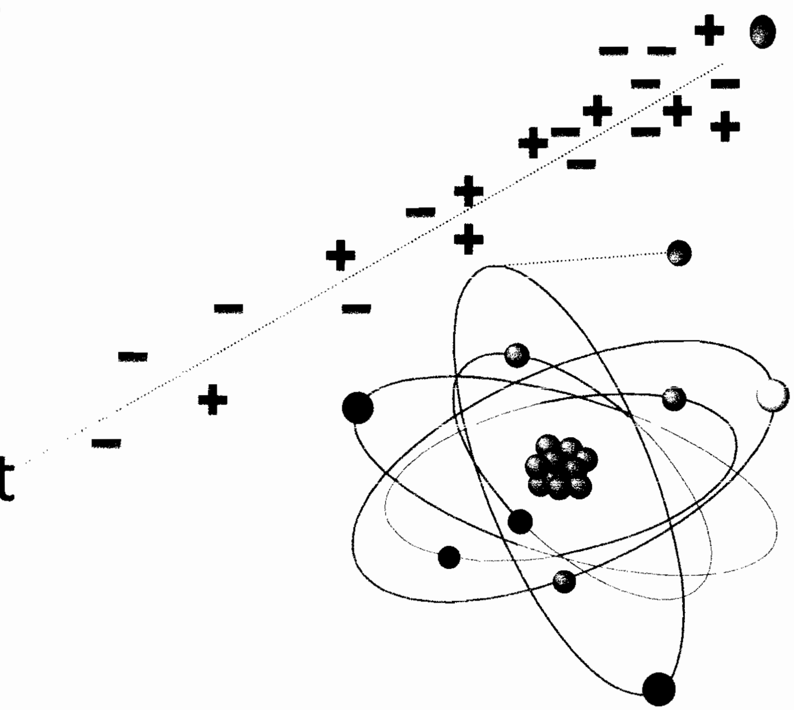
Purpose

- Provide for the protection of the University population, general public, and environment against radiation hazards associated with CUA's possession, use, transportation, and disposal of radioactive material.
- Provide for the University's compliance with NRC and other applicable radiation protection regulations.

Radiation

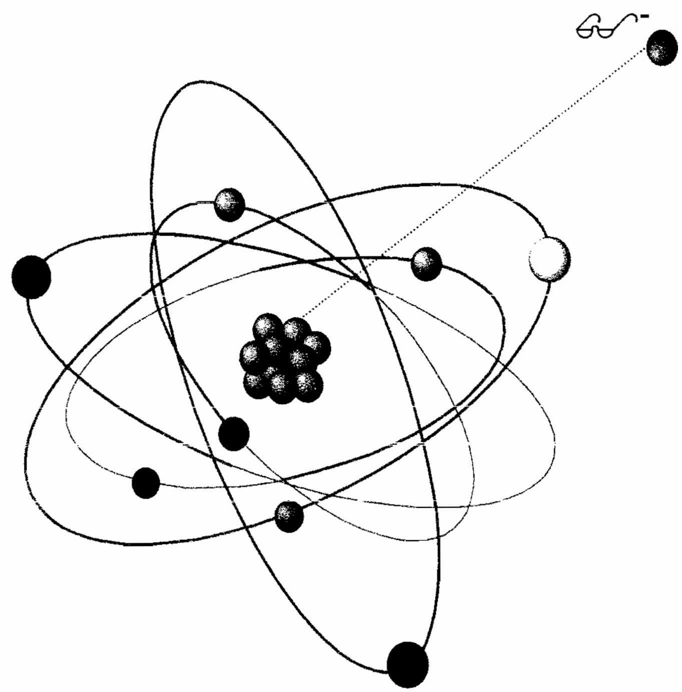
- Radiation: Energy in the form of particles or electromagnetic waves

- Ionizing Radiation: Radiation with sufficient energy to remove an electron from an atom or molecule.



Radioactivity

- The process by which unstable atoms spontaneously transform to new atoms* and in the process emit radiation.



* The "new atom" may be the same atom in a lower energy state.

Units of Activity

- **Curie (Ci):** 37 Billion transformations per second. (2.22 trillion per minute)
- **Bequerel (Bq):** 1 transformation per second.

mCi and uCi are common quantities used in the lab (10 uCi up to 50 mCi).

0.0013 uCi (48 Bq) - Ra-226 in a 1 kg rock
0.12 uCi (4400 Bq) - K-40 in your body
330 pCi - C-14 in ¼ lb of beef

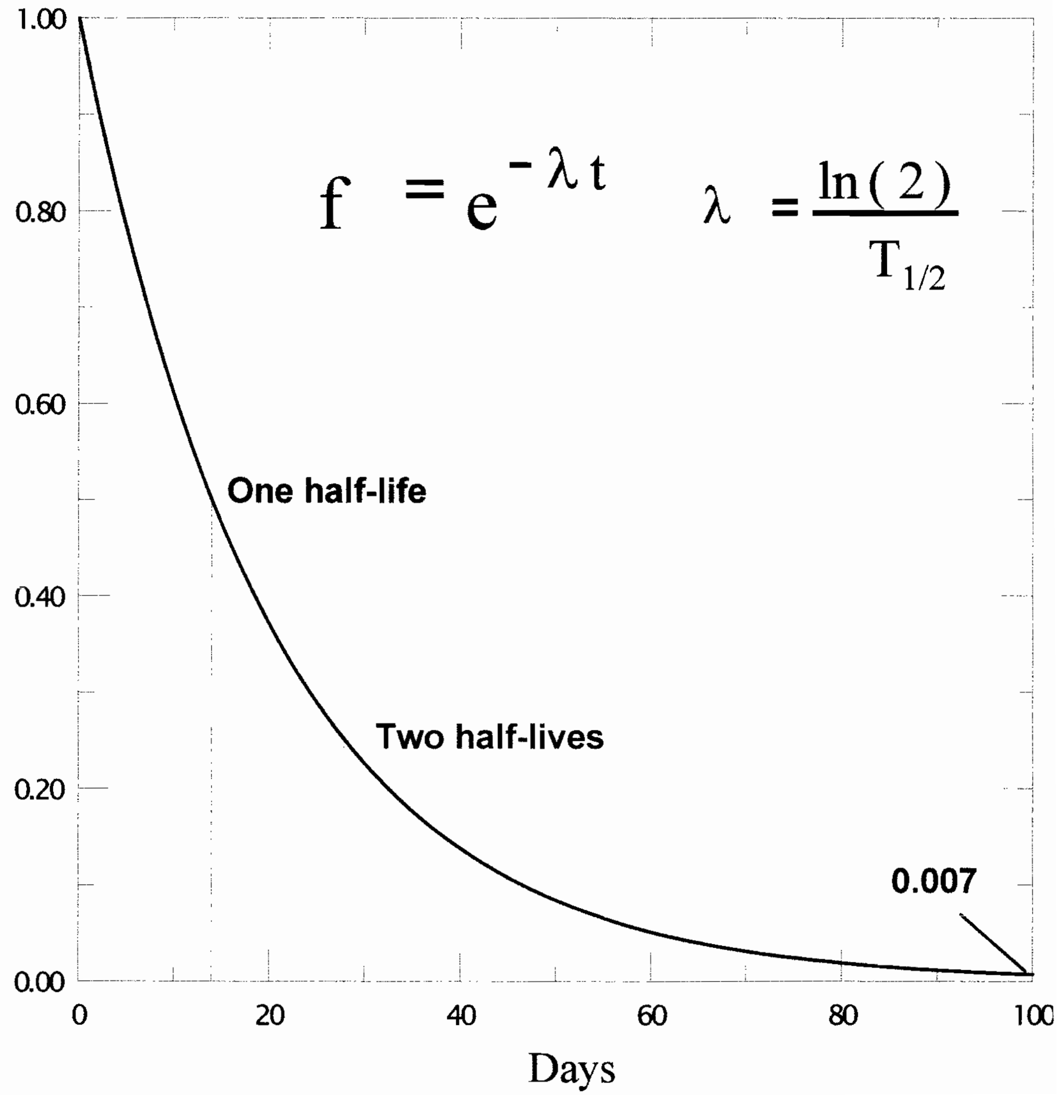
Natural Radioactivity in Your Body

Nuclide	Activity
Uranium	30 pCi (1.1 Bq)
Thorium	3 pCi (0.11 Bq)
Potassium 40	120 nCi (4.4 kBq)
Radium	30 pCi (1.1 Bq)
Carbon 14	0.4 µCi (15 kBq)
Tritium	0.6 nCi (23 Bq)
Polonium	1 nCi (37 Bq)

Half-Life

- Half-life is the amount of time needed for the activity to reach one half of the original amount.

$$f = \left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}$$



Definitions

- **<u>Exposure</u>** R (roentgen): Amount of charge produced per unit mass of air from x-rays and gamma rays.
- **<u>Absorbed Dose</u>** rad: Amount of Energy deposited per unit mass of material. 1Gy = 100 rad.
- **<u>Dose Equivalent</u>** rem: Risk adjusted absorbed dose. The absorbed dose is weighted by the radiation type and tissue susceptibility to biological damage. 1 Sv = 100 rem.
- Radiation weighting factors: alpha(20), beta(1), n(10).
- Tissue weighting factors: lung(0.12), thyroid(0.03), and gonads(0.25).

For whole body x or gamma-ray exposure

1 R ≈ 1 rad ≈ 1 rem

Types of Emissions

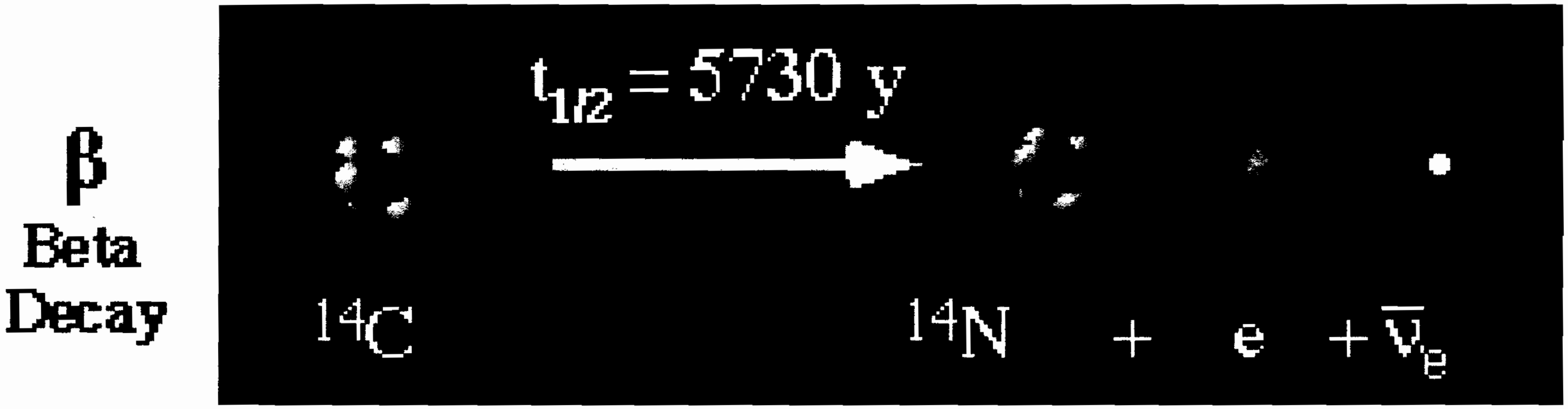
Alpha (α) decay $^{4}_{2}He$ or $^{4}_{2}\alpha$

A doubly ionized helium atom released from the nucleus.

Example of α Decay

$$^{226}_{88}Ra \longrightarrow ^{222}_{86}Rn + ^{4}_{2}\alpha$$

Beta Decay



- Energetic electron – singly ionized
- External hazard to skin and eyes
- Internal hazard via ingestion or inhalation of beta emitter
- Produces bremsstrahlung radiation
- A 1 MeV beta can travel up to 12 feet in air and 1 cm in plastic
- Phosphorus, Tritium, Carbon, Sulfur

Gamma Decay

- X-rays and gamma rays are photons – no charge
- External radiation hazard to deep organs and tissues
- Internal hazard via ingestion or inhalation of gamma emitter
- Lead (high electron density) is good for shielding x and gamma rays
- Iodine 125 gammas (30 keV) can be easily stopped with 1/8 inch of lead

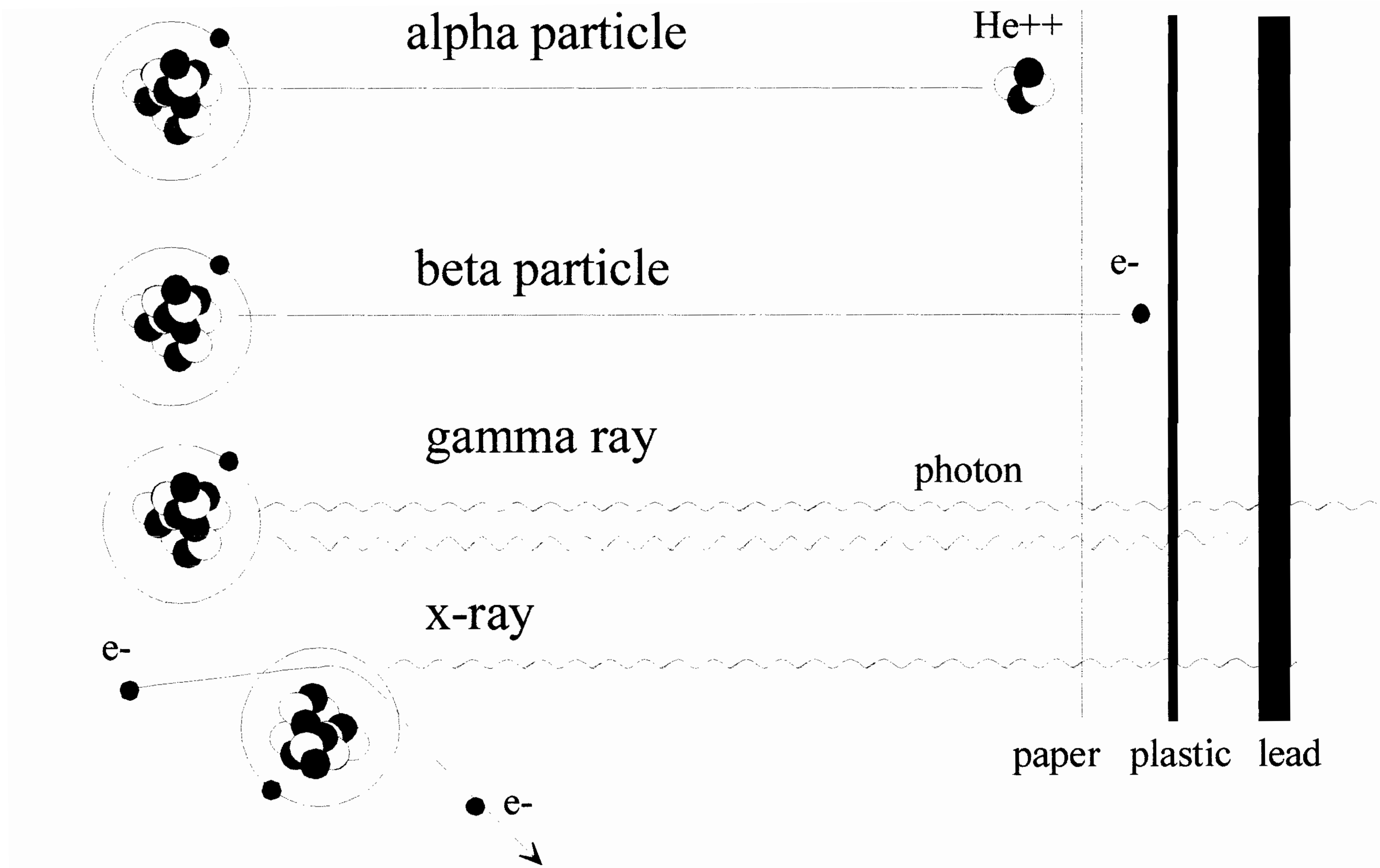
Types of Emissions (γ)

Gamma (γ) emission

$$^{238}_{92}U \longrightarrow \, ^{234}_{90}Th + \, ^{4}_{2}He + 2\gamma$$

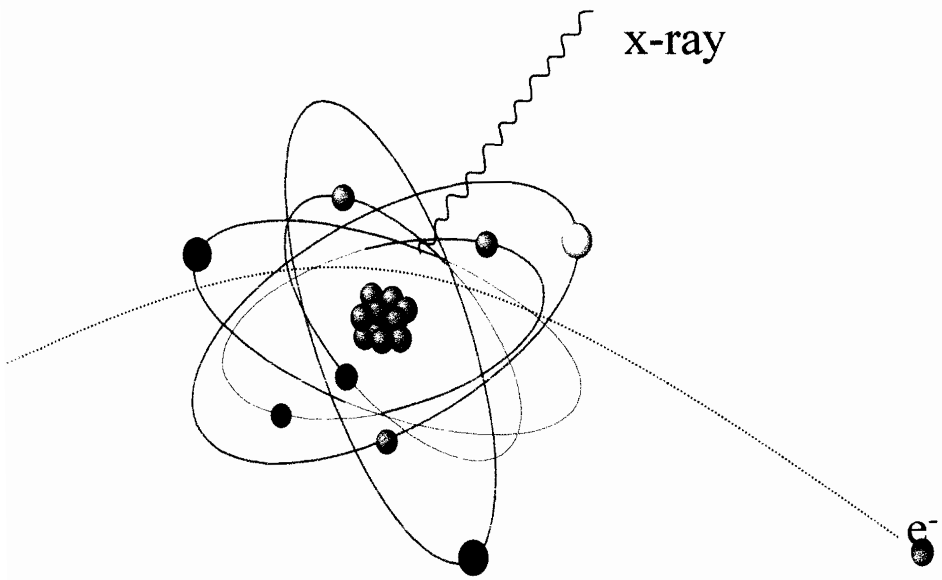
Gamma is a high-energy photon or particle of light with no mass. The exited nucleus relaxes.

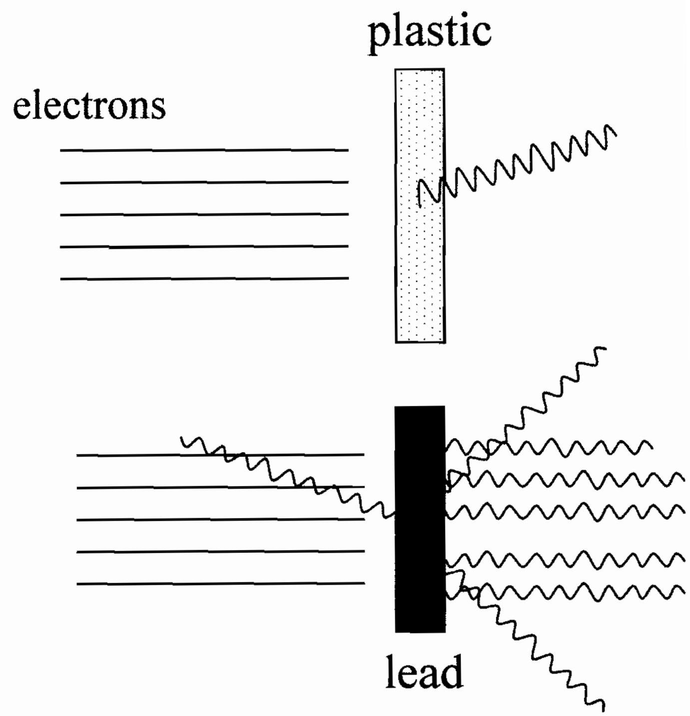
Uranium $\longrightarrow$ Thorium + Alpha particle emission + 2 gamma rays



Neutron shielding material depends on the energy of the neutrons

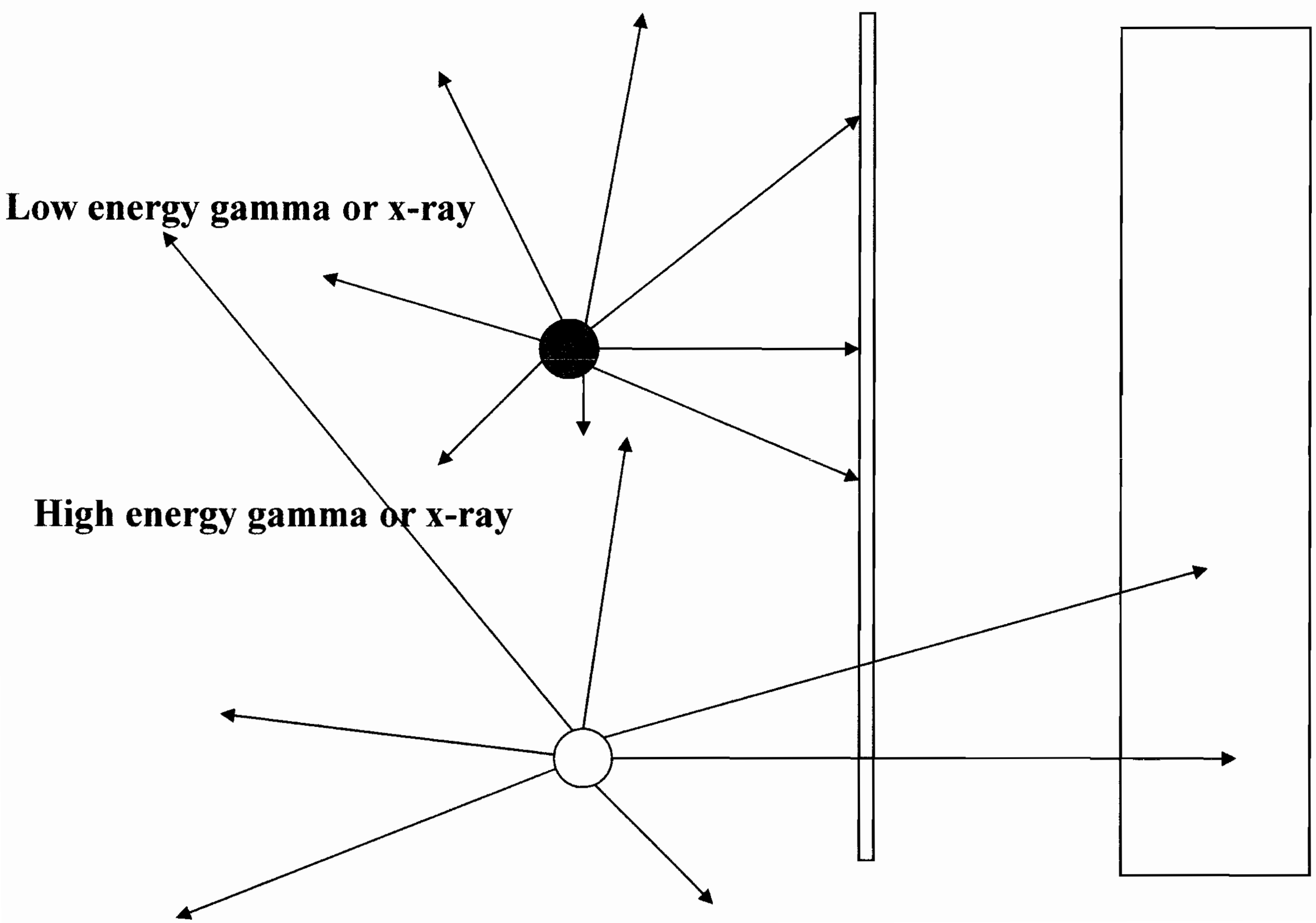
Bremsstrahlung X-Rays



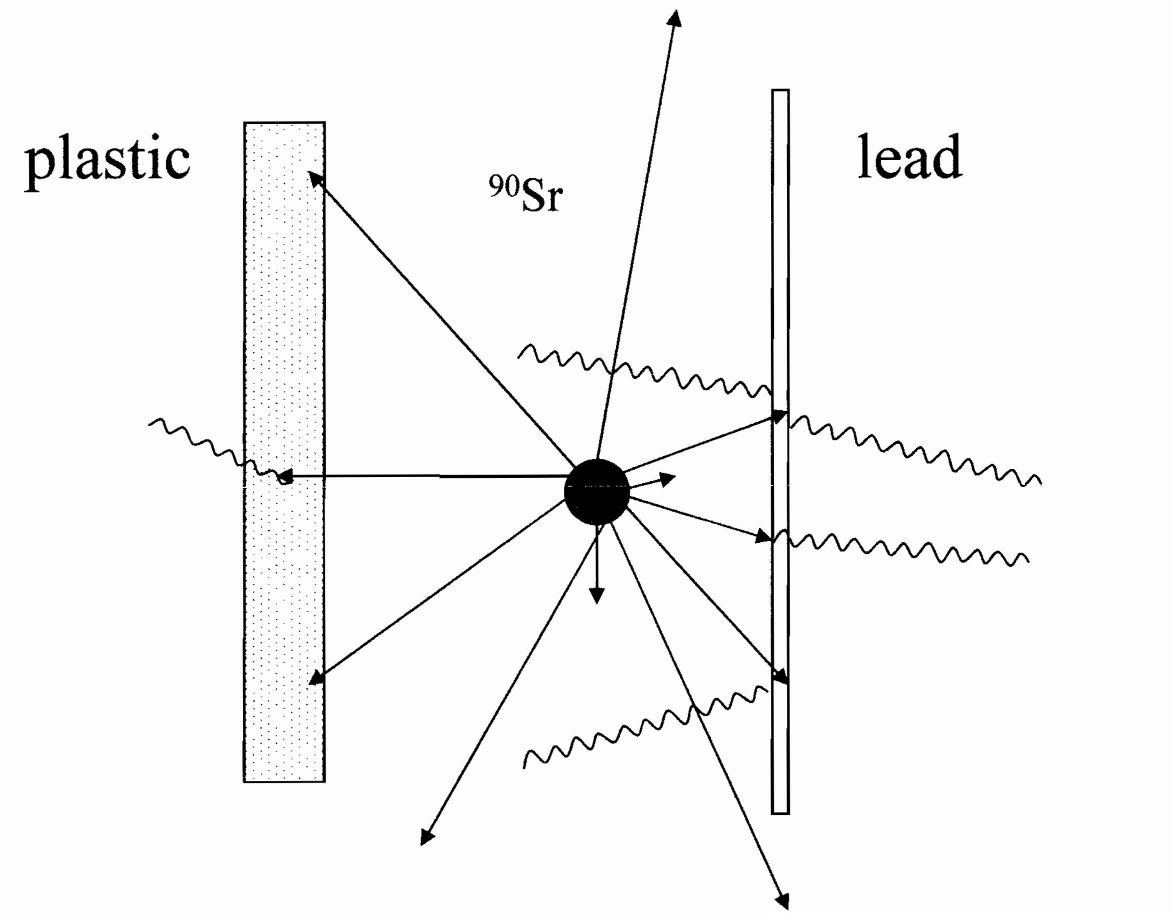


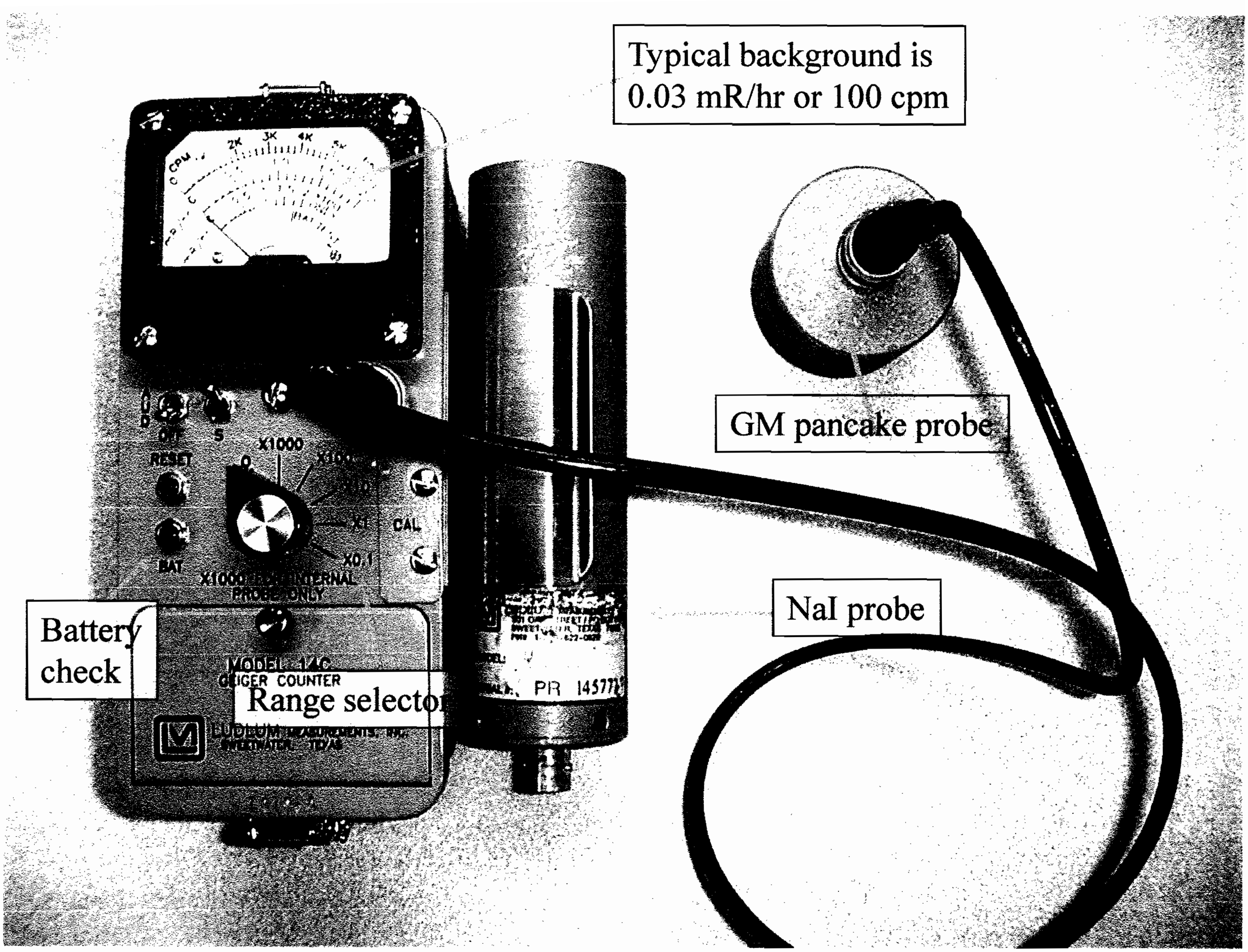
- Bremsstrahlung x-ray intensity increases with increasing atomic number of absorber, and the average x-ray energy increases with increasing electron energy.
  (activity of the source is also a factor)

Shielding for gamma emitting material



Shielding for beta emitting material

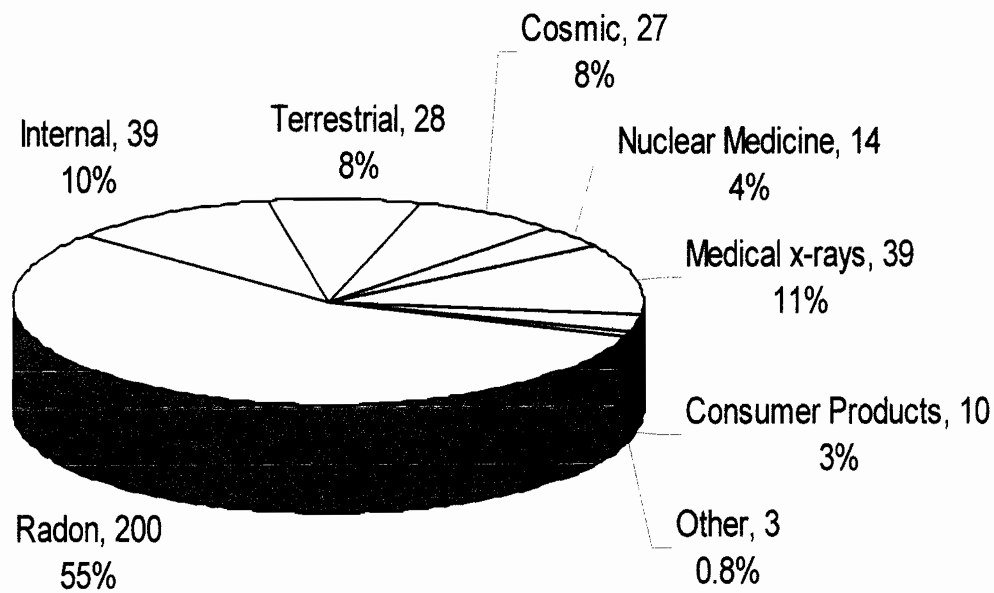



Typical background is
0.03 mR/hr or 100 cpm
GM pancake probe
NaI probe
Battery check
Range selector
CPM
X1000
X100
X1
X0.1
CAL
RESET
BAT
GEIGER COUNTER
PR 14577

Background Radiation

360 millirem per year

Sources of Average Radiation Dose to the U.S. Population



Source: BEIR V Report, 1990

Annual Occupational Dose Limits

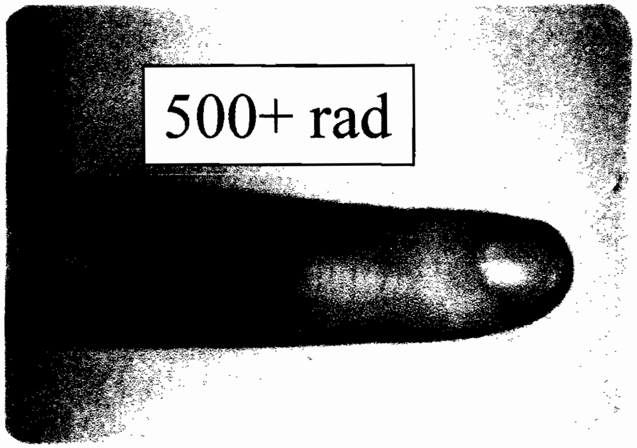
Whole Body	5,000 mrem/year
Lens of the eye	15,000 mrem/year
Extremities, skin, and individual tissues	50,000 mrem per year
Minors	500 mrem per year (10%)
Embryo/fetus*	500 mrem per 9 months
General Public	100 mrem per year

* Declared Pregnant Woman

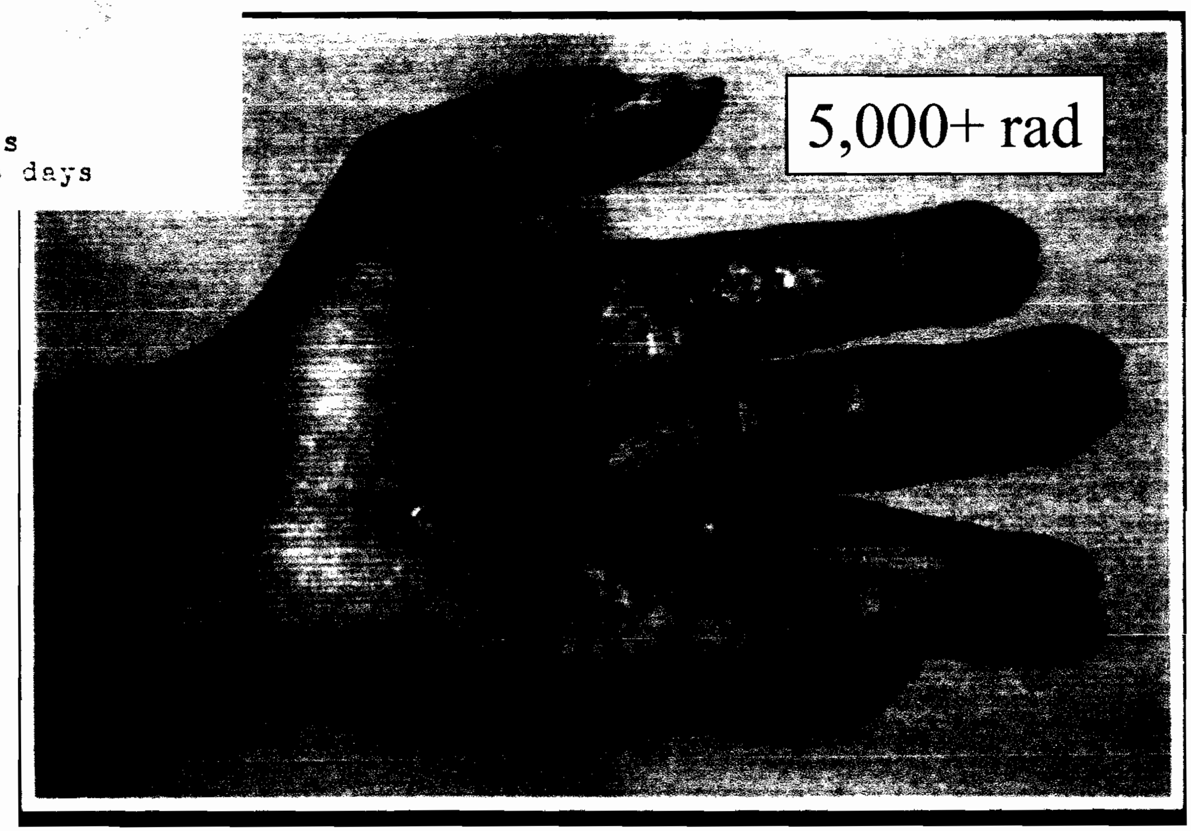
Biological Effects

- Many groups exposed to ionizing radiation at high levels resulted in adverse effects.
- Somatic effects
  - Prompt - skin burns and cataracts
  - Delayed - cancer
- Genetic effects
- Teratogenetic effects

X-Ray Burns



Exposure of 5-10 seconds
Appearance of wound after 25 days

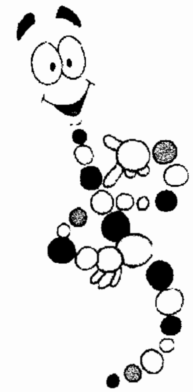


P-32 - 6.5 rad/hr/uCi

S-35 - 2.5 rad/hr/uCi

Cancer

- Radiation can damage cells through two methods;
  - Production of free radicals and
  - Direct damage to the DNA.
- Risk factor for radiation dose:
  - 4% increase in risk of dying of cancer for every 100 rem of dose.
  - Normal cancer risk is 20%.

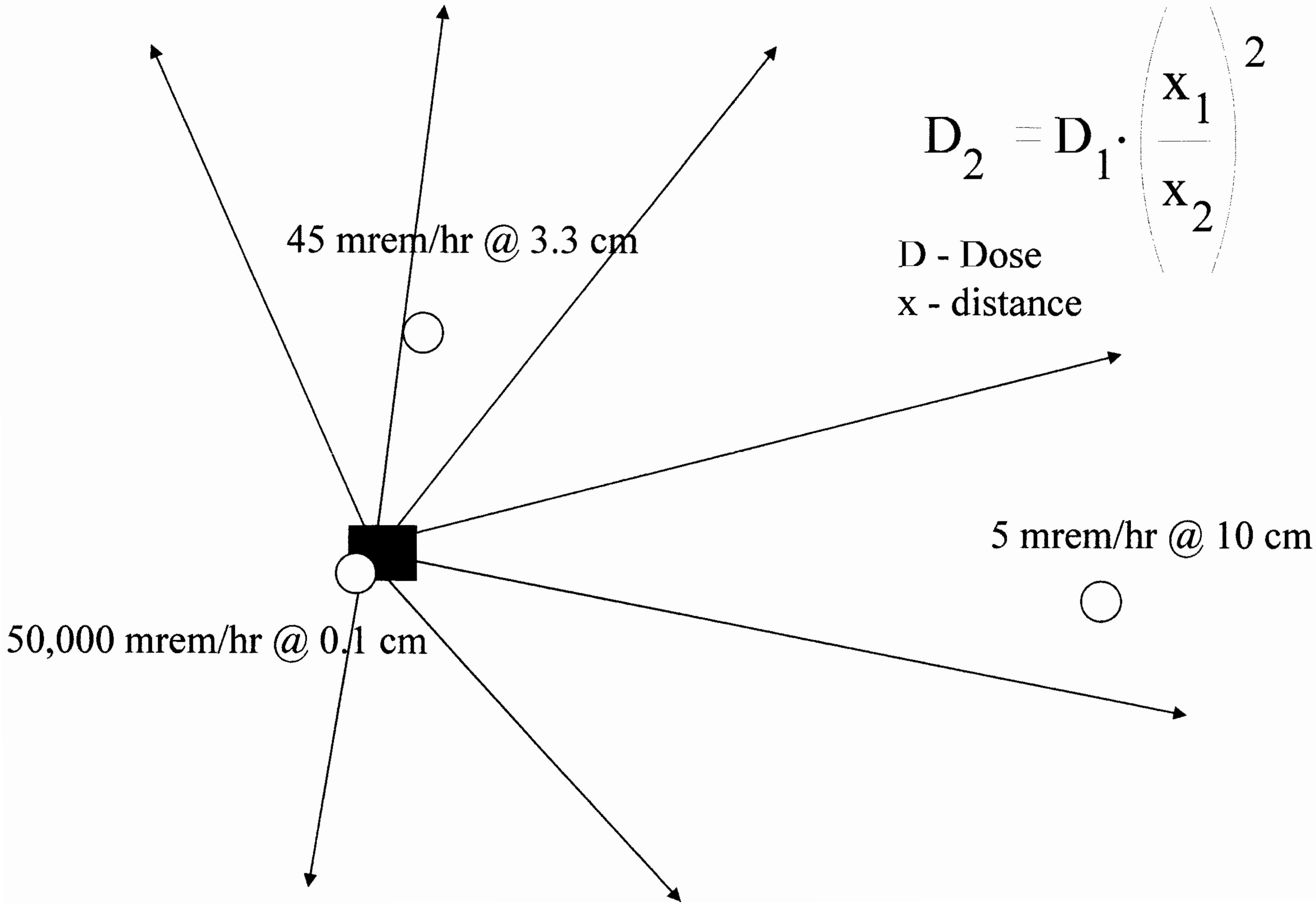


ALARA

- ALARA - As Low As Reasonably Achievable

- <u>Time</u>
- <u>Distance</u> (inverse square law)
- <u>Shielding</u>
- <u>Contamination Control</u>

Inverse Square Law



$$D_2 = D_1 \cdot \left(\frac{x_1}{x_2}\right)^2$$

D - Dose
x - distance

Radioactive Sealed Sources

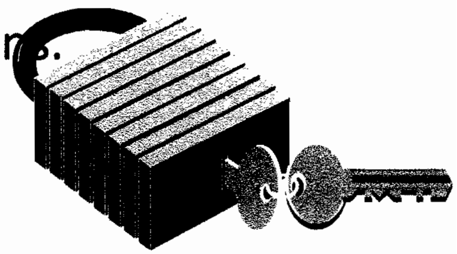
- Sealed sources used as a source of radiation
  - Alpha particles
  - Beta particles
  - Gamma ray
  - Bremsstrahlung
  - Neutron sources
- Permanently enclosed in either a capsule or another suitable container designed to prevent leakage or escape of the radioactive material
- Inventory and Use records are required

Radioactive Sealed Sources

- Tested for surface contamination and leakage
  - Sources may leak radioactive material
  - Tested usually once every 6 months for beta & gamma emitters that are ≥ 100 uCi
  - Tested every 3 months for alpha emitters ≥ 10 uCi
  - Allowable limit is less than 0.005 uCi
- A leaking source shall immediately be removed from use
  - Action to be taken to prevent contamination
  - Source to be repaired or disposed of
- RPP has a shielded storage facility for sources that are not in use.

Security and Transportation

- All radiation sources must be kept locked up when not in use.
- Experiments left unattended should be labeled “Experiment in Progress.”
- An up-to-date use log of all sources must be kept at the storage location.
- All radiation laboratories will be locked when unattended for extended periods.
- When you are the means for security, you must challenge unknown persons entering the lab.
- Sources can only be used in a registered radiation laboratory.
- Call RPP for all transfers of sources to other authorizations.



General Radiation Safety

- **<u>No</u>** food or beverages in the lab
- Keep a survey meter conveniently close by
- ALARA - time, distance, and shielding
- Label radioactive materials and equipment

Experimental Setups

Moessbauer Spectroscopy

- 10 mCi ^{57}Co source (122 keV gamma)
- Exposure Rates
  - 9000 mR/hr at 1 cm
  - ~1 mR/hr at 3 feet
- With shielding
  - Background levels

E/M experiment

- 10 mCi $^{90}Sr/Y$ (b) and 110 uCi ^{133}Ba (g) source
- Exposure Rates
  - $^{90}Sr/Y$ - skin
    - 9000 mrad/hr to skin
  - ^{133}Ba – whole body
    - 2.6 mR/hr at 10 cm

Experimental Setups cont…

Alpha Decay

- Natural U, Th, and Ra in rocks
- Exposure Rates
  - 0.1 mR/hr at 1 foot
  - Contact 3mR/hr - gamma
  - Contact 35 mrad/hr - beta

Compton Scattering

- 500 uCi ^{137}Cs source
- Beta and gamma emitter
- Exposure Rates
  - 1.5 mR/hr at opening
  - 0.15 mR/hr on contact with lead
  - Background levels in area

Experimental Setups cont…

Rutherford Scattering

- 165 uCi ^{241}Am source
- Alpha and gamma emitter
- Alpha 5.5 MeV
- Gamma ~ 60 keV

- Many smoke detectors have 1 uCi of ^{241}Am

Conduct of work - Good Practice

Personal Preparation

Requirements of Posted Contamination Areas

Dosimetry

Personnel Protective Clothing (Anti-Contamination)

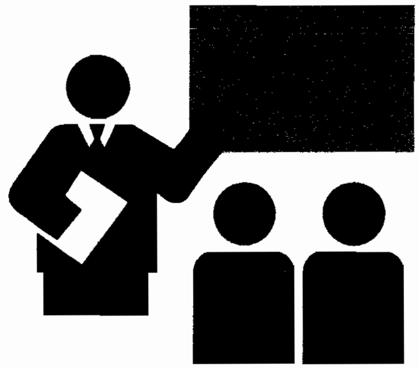
Storage and Containment of Radioactive Material

Good House Keeping

Special Precautions for Liquids

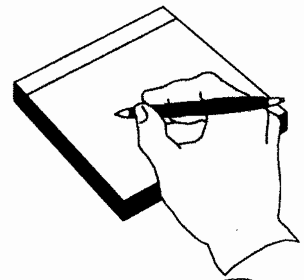
Personal Preparation

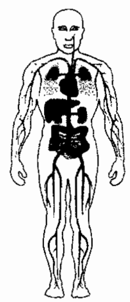
- Training to meet entry requirements
  - Has the basic training to enter the facility and perform the assigned activities using radiation sources
- Knowledge of the Standard Operating Procedures
  - Has read and understands the SOP for the assigned task. May also need to have developed the necessary skills to perform the task.
- Appropriate Dosimetry
  - Most often personal monitoring is required. The actual method varies with the hazards associated.
- Personal Protective Equipment
  - The appropriate equipment is most critical when working with radiation sources which are internal hazards.



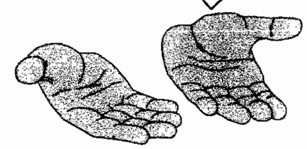
Training

Procedures





Dosimetry



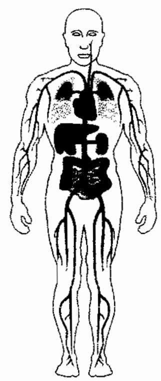
Personal Protective Equipment

Requirements for Posted Contamination Areas

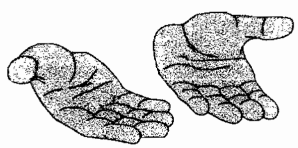
- Requirements for entry
- Requirements for working in the area
- Requirements for exiting the area

Dosimetry

- Whole body

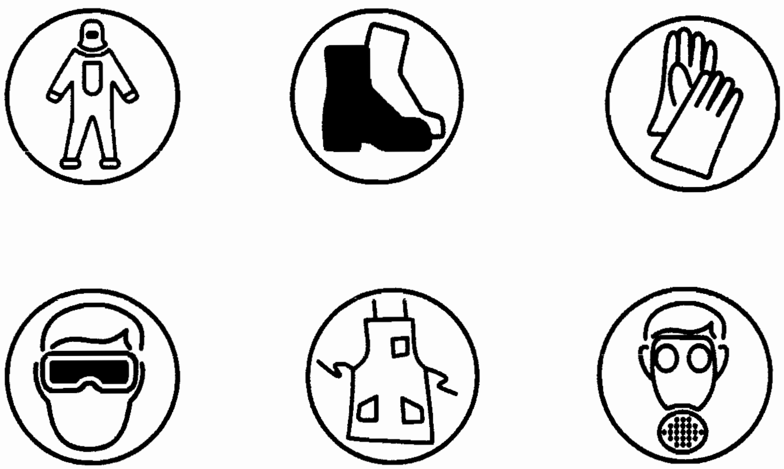


- Extremity monitoring



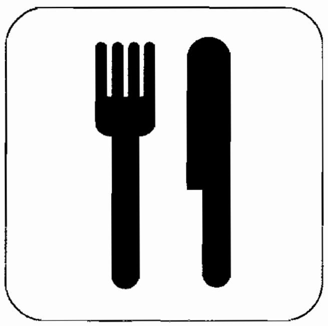
Dosimetry records are medical records

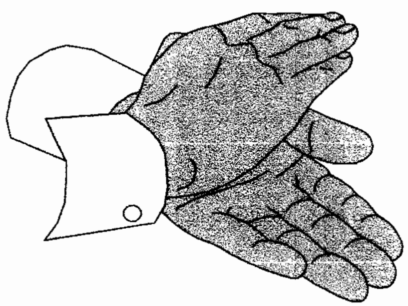
Personnel Protective Clothing (Anti-Contamination)



- Proper use of protective clothing
- Eye protection
- Respiratory equipment

Good Practices





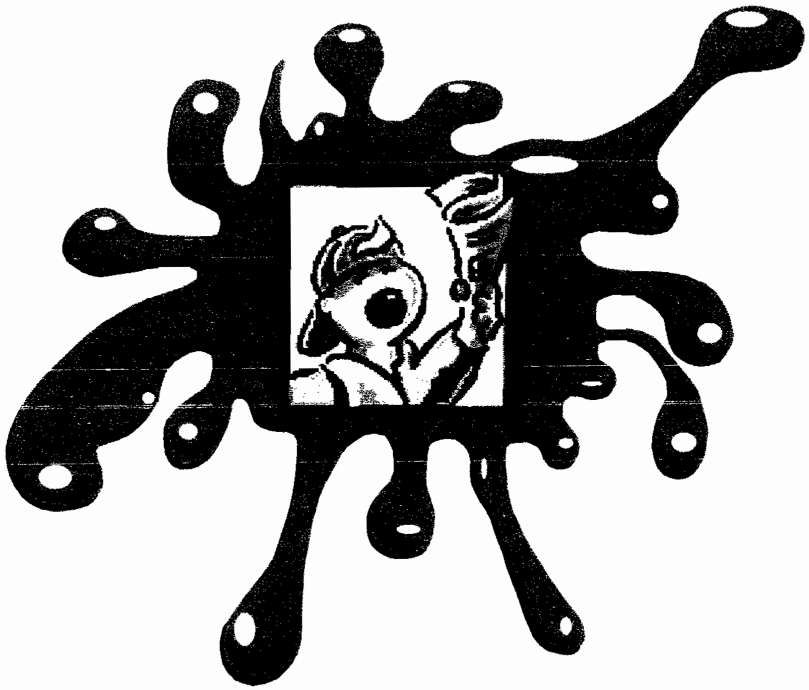
- **Believe** labels and posted areas.
- Avoid contamination and airborne radioactive areas.
- Treat radiological areas as if everything were contaminated.
- Use proper and functional detection instruments.
- Do not eat, drink, apply makeup or chew gum.
- Always wash hands upon completion of work.

Good House Keeping

Good house keeping is the prime factor in an effective contamination control program.

It involves the interactions of all groups within the facility.

Each individual must be dedicated to keeping his/her house clean to help control the spread of contamination.



Radiological Contamination

Radiation versus Contamination

Types of Contamination

Units of Radioactive Contamination

Causes of Radioactive Contamination

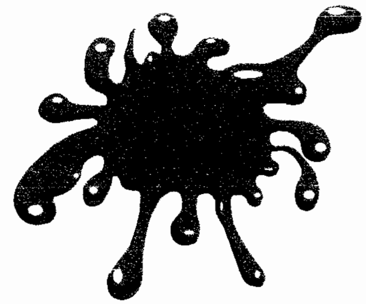
Indicators of Possible Area Contamination

Primary Reasons for Contamination Control

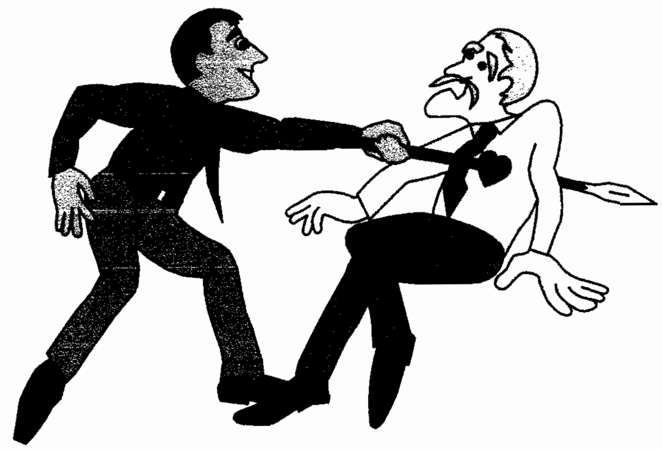
Contamination Control Measures

Radiation Versus Contamination

Contamination
Radioactive material where you don't want it.



Radiation (exposure)
Energy passing through something.



Just because you are exposed does not mean that your are contaminated. However, if you are contaminated, you continue to be exposed.

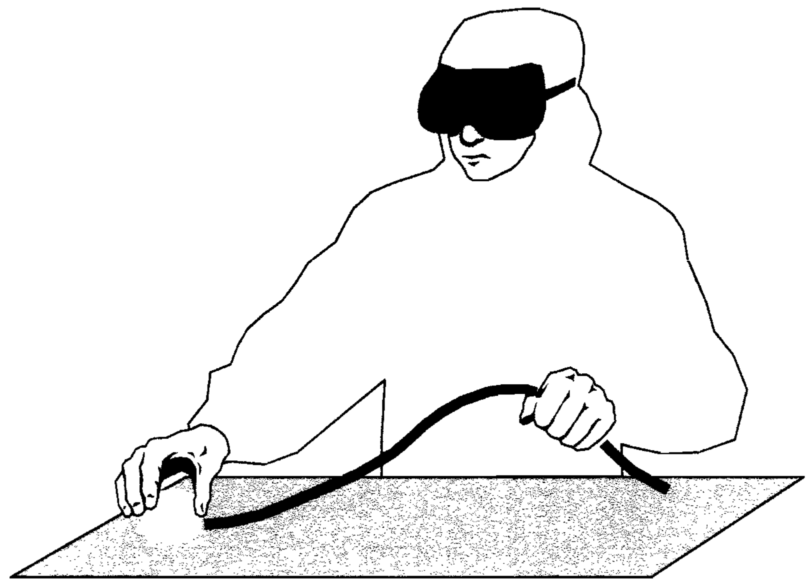
Contamination Control

One of the most important aspects of radiological protection.

Ensure a safe working environment

Types of Contamination

Three types of contamination:

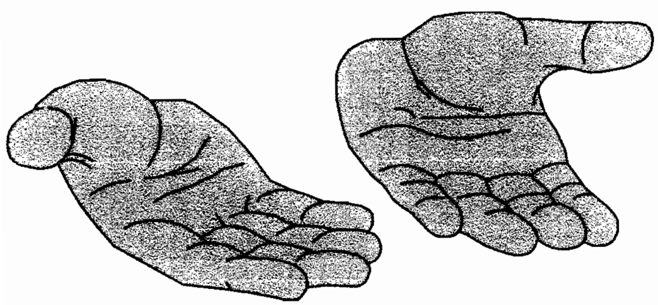


- Fixed
- Removable
- Airborne

Modes of Entry into the Body

Inhalation

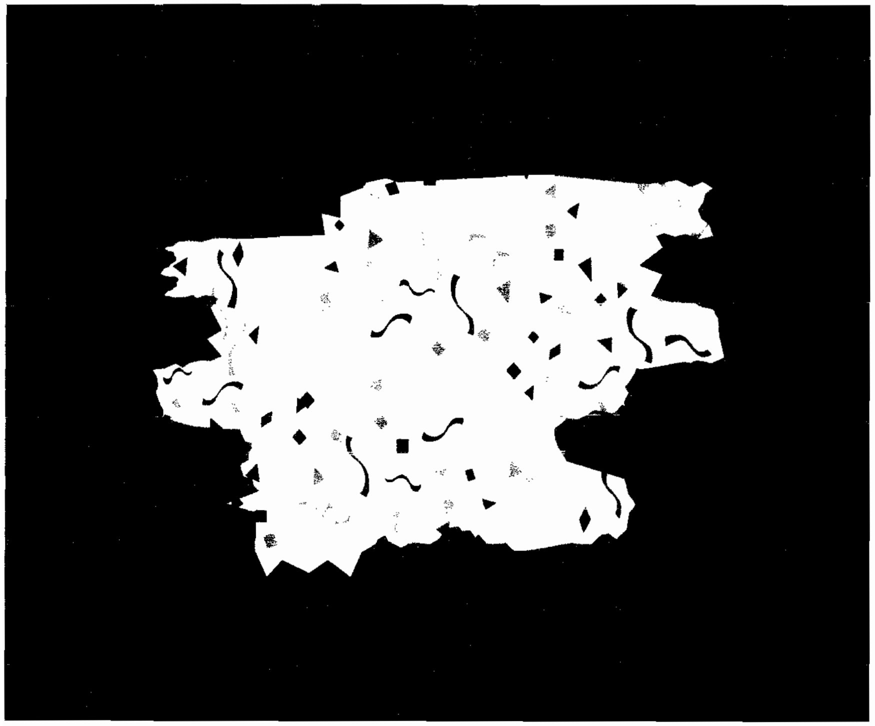
Ingestion



Absorption

Wounds

Causes of Contamination



- Opening systems without proper controls
- Airborne sources
- Leaks or tears
- Poor housekeeping
- Excessive motions in higher contamination areas
- Sloppy work practices

Indicators of Possible Contamination

- Leakage
- Spills
- Splashing
- Aerosols
- Vapors
- Dusts
- Manual contact & transfer

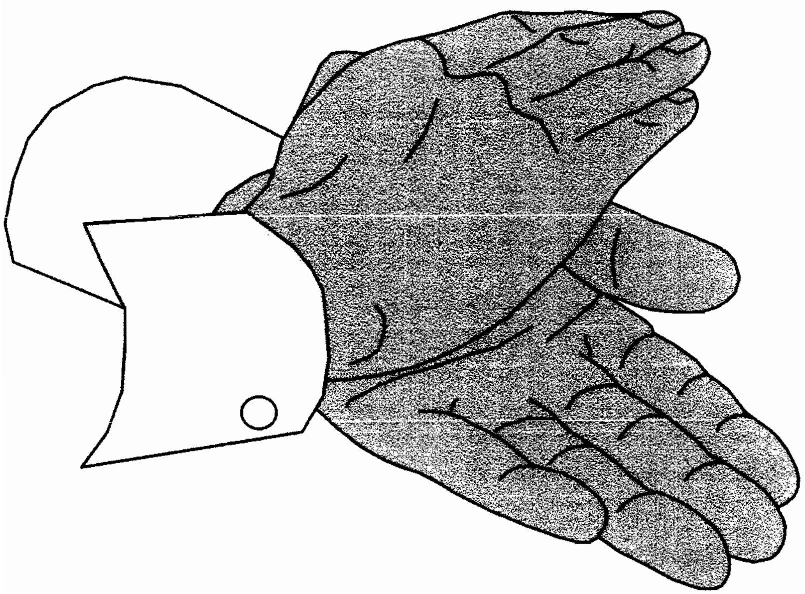
Indicators of Possible Area Contamination

- Elevated radiation levels
- Unexplained personnel contamination
- Radioactivity observed in bioassay samples
- Higher than normal background
- Airborne monitor alarms

Control Methods

- Administrative
  - Signs, barriers, procedures, etc.
- Engineering
  - Ventilation, shields, alarms, containment, PPE, etc.
- Training
  - Classroom (formal and informal), procedural, notices, etc.

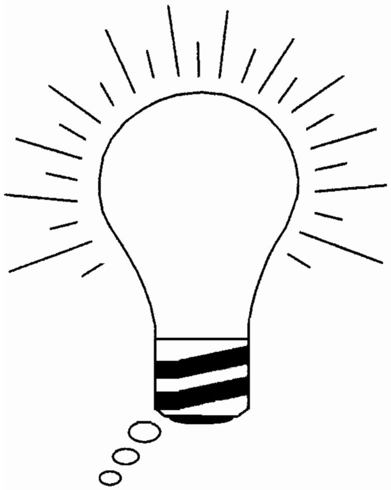
Decontamination



Removal from locations where it is not wanted

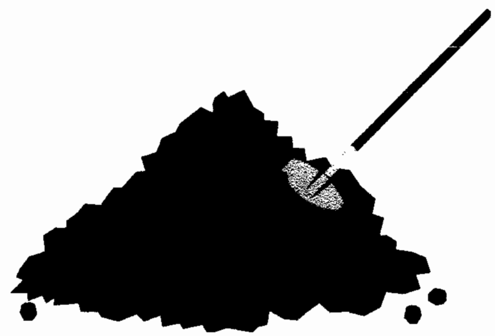
- Equipment
  - Removal from surface
  - Wash and wear
- Skin or internal
  - Notify RSO
  - Wash with mild soap and luke warm water

Radiation Versus Contamination



Radiation is energy

Contamination is material
(where you don't want it)



Units of Radioactive Contamination

- Direct reading
  - Counts per minute (CPM)
  - (what your instrument sees)
- Indirect reading
  - Disintegrations per minute (DPM)
  - (what you get or how much activity is there)

CPM / DPM = efficiency

Primary Reasons for Contamination Control

- Protect the worker
- Radioactive materials may enter the body
- Protection of the environment
- Protection of the facility and programs
- It's the law

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RADIATION SAFETY MANUAL **February 2012**

EMERGENCY TELEPHONE NUMBERS

FIRE/AMBULANCE*	9-911
CAMPUS POLICE	5111
ENVIRONMENTAL HEALTH AND SAFETY OFFICE	5789
POISON CONTROL CENTER	1800-222-1222
RADIATION SAFETY OFFICE	5206

* Campus Police must be notified immediately after any call for fire or emergency assistance.

EMERGENCY PROCEDURES FOR RADIATION SAFETY ARE FOUND IN SECTION 9.5, BEGINNING ON PAGE 36 OF THIS MANUAL.

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9.0 PROMULGATION

Under licenses issued by the Nuclear Regulatory Commission (NRC), The Catholic University of America is authorized to possess and use defined sources of ionizing radiation for research and experimental purposes. These licenses require that CUA establish and maintain an active Radiation Safety Committee (RSC), a program for radiation safety, and a Radiation Safety Manual.

As in every safety program, the primary responsibility for maintaining personnel and environmental safety lies with the individual worker. Therefore, all persons who work with sources of ionizing radiation at the University shall comply with the provisions contained in this manual and the regulations of both the Nuclear Regulatory Commission and the District of Columbia.

This document comprises the Radiation Safety Manual for The Catholic University of America and supersedes all previous editions, which are now obsolete.

9.1 ORGANIZATION FOR RADIATION SAFETY

9.1 ORGANIZATION FOR RADIATION SAFETY

The organization for radiation safety at The Catholic University of America consists of the Radiation Safety Committee (RSC), a Radiation Safety Officer (RSO) who operates the Radiation Safety Office and assists the RSC in discharging its responsibilities, the Deans, Department Chairs and Laboratory Directors within whose jurisdictions work with sources of ionizing radiation is conducted, Authorized Users who receive their authorizations from the RSC, and Individual Users who work under the supervision of Authorized Users.

9.1.1 Radiation Safety Committee

9.1.1.1 Establishment

The Radiation Safety Committee of The Catholic University of America is established by the Provost of the University. The purpose of the RSC is to ensure that all sources of ionizing radiation at CUA are used safely and in a manner which complies with applicable regulations of the Federal Government and the Government of the District of Columbia, so that the individual user, the University population and the general public are protected.

The RSC reports through its chair to the Associate Vice President for Facilities Operations and monitors the operations of the University Radiation Safety Officer.

9.1.1.2 Responsibilities

The Radiation Safety Committee shall:

a. Annually review the University Radiation Protection Program and recommend appropriate changes to the Associate Vice President for Facilities Operations;

b. Assist the RSO to establish an effective radiation protection program in compliance with applicable regulations and University policy;

c. Assure that each authorized user is qualified by training and experience, has the facilities to use the material or equipment safely, and proposes a use which is safe for all concerned;

d. Review instances of alleged infractions of regulations for the safe use of sources of ionizing radiation and recommend remedial action if appropriate (this responsibility extends to on-campus projects conducted by non-University organizations or individuals);

e. Ensure the maintenance of all records required by law or regulation due to the presence or use of sources of ionizing radiation on the campus.

9.1.1.3 Authority

To meet its responsibilities, the RSC is given the following authority:

a. To grant or deny authorization to an individual, or to any University or non-University organization for the use, on CUA property, of radioactive material or radiation-producing equipment;

b. To prescribe the conditions for use on CUA property of sources of ionizing radiation, including requirements for bioassay and/or physical examinations of users, special effluent control devices, minimum level of user training and experience, and restrictions on the amount of occupational exposure which an individual may be permitted to receive during his or her CUA association;

c. To suspend or terminate any project or procedure on CUA property involving the use of sources of ionizing radiation which it finds to be a threat to health or property.

9.1.1.4 Membership

The RSC consists of the Chair and additional members as indicated below. Appointments to the RSC are made by the Executive Vice President with the advice of Department Chairs, Deans and the RSO.

a. Ex-Officio Members
   - Chair
   - Director of Environmental Health and Safety
   - Representative from Maintenance and Operations
   - Radiation Safety Officer

b. Technical Members
   One member, qualified by training and experience in the use of radioactive material or radiation-producing equipment is appointed from each Department/Laboratory which makes extensive use of sources of ionizing radiation.

9.1.1.5 Meetings

The RSC shall meet at least once per semester and at least monthly if a proposal for the use of a source of ionizing radiation is pending RSC review. An affirmative vote of two-thirds of all members of the RSC is required to approve an application for use of a source of ionizing radiation.

9.1.1.6 Records

The formal record of the RSC is the minutes of its meetings. The minutes shall contain a record of all recommendations and actions of the RSC, together with such additional material as the Chair shall deem appropriate for completeness. The minutes shall be maintained throughout the life of the license by the RSO.

9.1.2 <u>Radiation Safety Officer</u>

9.1.2.1 Appointment

The Radiation Safety Officer (RSO) is a staff employee of the University appointed by the Associate Vice President for Facilities Operations and functions as technical advisor to the RSC Chair.

9.1.2.2 Responsibilities

The RSO shall implement the CUA Radiation Safety Program. To that end the RSO shall:

a. Annually review the CUA Radiation Protection Program and recommend, for RSC consideration, appropriate changes in order to maintain the program in compliance with applicable regulations and the radiation exposure of radiation workers and the general public as low as is reasonably achievable (ALARA);

b. Control the procurement, transport, storage, use and disposal of radioactive material and radiation-producing equipment for the University;

c. Determine the suitability of space, facilities, or equipment for the storage or use of radioactive material;

d. Ensure that all CUA facilities which relate to the presence of sources of ionizing radiation on the campus are inspected and surveyed or monitored to determine compliance with regulations and license requirements;

e. Ensure that periodic leak tests are performed as required on all sealed sources of ionizing radiation owned or possessed by the University or used on the campus;

f. Provide appropriate personnel radiation exposure monitoring devices and radiation survey instruments;

g. Ensure that any reported or suspected radiation hazard, incident, or overexposure at CUA is investigated, reported as may be required, and corrected if necessary;

h. Maintain all records pertinent to the radiation protection program, to include:

- Receipt, distribution and disposal of radioactive material,
- Inventory of radioactive material and radiation-producing equipment,
- Radiation surveys and leak tests of sealed sources,
- Registry of radiation workers,
- Radiation exposure,
- Licenses for CUA possession and use of radioactive material;

i. Prepare all reports required by law or regulation as a result of CUA possession and use of sources of ionizing radiation;

j. Assist users of sources of ionizing radiation in their programs by:

- Reviewing their plans for research and test programs involving use of sources of ionizing radiation;
- Providing consultation on laboratory design, shielding, and other radiation exposure control methods;
- Reviewing all applications for new or amended authorizations and submitting comments and recommendations to the RSC;
- Preparing timely applications for renewal or amendment of CUA licenses for the possession and use of radioactive material;
- Assisting in the development of appropriate radiation safety procedures;
- Providing calibration and minor repair service for radiation survey instruments;
- Providing appropriate signs for restricted areas;
- Providing supervision and assistance with respect to radiation emergencies and special

decontamination procedures;

- Reporting all instances of non-compliance with regulations for the control of sources of ionizing radiation to the RSC;
- Recommending remedial action to correct radiation safety infractions;

k. Operate the CUA Radiation Safety Laboratory (RSL) to provide the technical support required to discharge other RSO responsibilities. The RSL may also be used for the conduct of research by or under the supervision of the RSO, subject to the same requirements for RSC authorization as are established for other CUA users of sources of ionizing radiation.

9.1.2.3 Authority

To discharge assigned responsibilities, the RSO is granted the following authority:

a. To enter any space where a source of ionizing radiation is stored or used;

b. To seize any radioactive material which is being stored or used in a manner perceived to represent a threat to persons or property;

c. To suspend any operation with a source of ionizing radiation found to be in violation of the user's authorization;

d. To deny permission to procure radioactive material to any user whose radioactive material inventory is not current.

9.1.3 <u>Department Chairs and Laboratory Directors</u>

Chairs and Directors shall require compliance with applicable radiation safety regulations with respect to the personnel and facilities under their jurisdiction;

9.1.4 <u>Authorized Users</u>

9.1.4.1 Definition

An Authorized User is defined as an individual who has been authorized by the RSC to conduct or direct a research or teaching project utilizing radioactive material or radiation-producing equipment.

The Authorized User is the key link in the organization for radiation safety. The Authorized User is expected to have both the expertise and the knowledge of day-to-day operations to ensure that all work is conducted safely.

9.1.4.2 Responsibilities

Authorized Users shall conduct their work in accordance with the CUA Radiation Safety Manual and applicable Federal and DC regulations; they shall cultivate in themselves and others an awareness of the potential hazards in their research or other activities; and they shall provide adequate facilities, equipment, instruments, supervision and instructions to control radiation hazards. To assist them in the discharge of their responsibilities, further guidance is provided in Section 9.3.15.

9.1.4.3 Authority

9.1 ORGANIZATION FOR RADIATION SAFETY

Each Authorized User has the authority, with respect to sources of ionizing radiation for which he/she is responsible, to:

a. Suspend, pending appropriate review and instruction, the work of any employee, student, or co-worker which is perceived to be a threat to health or property or to be in violation of regulations.,

b. Take immediate possession of any source of ionizing radiation for which he/she is responsible which is being used or stored in an unsafe manner.

9.1.5 Individual Users

9.1.5.1 Definition

An Individual User is defined as any person who works with sources of ionizing radiation under the supervision of an Authorized User.

9.1.5.2 Responsibilities

Individual Users shall conduct their work in accordance with the CUA Radiation Safety Manual and applicable Federal and DC regulations. Individual Users shall have primary responsibility for their own radiological safety and for ensuring that their exposure to ionizing radiation is maintained as low as is reasonably achievable (ALARA).

9.2 ADMINISTRATIVE PROCEDURES

The administrative procedures prescribed herein are intended to facilitate University compliance with applicable regulations for the control of radioactive material and exposure to ionizing radiation. Authorized and Individual Users are required to comply with these procedures. Any individual who observes practices or conditions with respect to radioactive material or radiation-emitting equipment, which are believed to be unsafe, should bring them to the attention of the cognizant Authorized User and RSO. In addition, any individual who believes that there is a violation of Nuclear Regulatory Commission (NRC) regulations or the terms of the University's licenses with regard to radiological safety conditions, may request an inspection by notifying Region I, Office of Inspection and Enforcement, US Nuclear Regulatory Commission, 1200 Renaissance Park, King of Prussia, Pennsylvania 19406, by letter or telephone (toll free at 1-800-432-1156). The request must set forth the specific grounds for the notice as explained in NRC Form 3.

NRC Form 3 -- NOTICE TO EMPLOYEES (reproduced in Appendix A) is required to be posted conspicuously to permit individuals working with radioactive materials to observe the form on the way to or from any particular licensed activity location. It is available from the RSO, full size, or may be reproduced from the reduced copy in the appendix.

Publications which are required by law or regulation to be made available to radiation workers are listed in Appendix A. They are available for inspection in the Radiation Safety Office, together with other publications which may be useful for planning for the safe use of sources of ionizing radiation.

9.2.1 Authority To Possess And Use Radioactive Material

No one may bring onto CUA property any radioactive material in amounts which would exceed license-exempt quantities (as defined in 10 CFR 30) without authorization from the RSC. A separate application is required for each project which contemplates the use of radioactive material. The scope of an application is the prerogative of the applicant; the scope of an authorization will be determined by the RSC based on its evaluation of the information provided, and the training, experience and facilities of the applicant.

9.2.1.1 Application for Authority to Possess and Use Radioactive Material or Radiation-Producing Equipment

Application shall be made on Form RSO-2 (Appendix B). Copies of the form are available from the RSO. Reapplication must be made when an increase in the authorized amount of activity of a previously approved isotope is desired, when a significant change of equipment or procedure is desired, or when additional isotopes are to be used. Instructions to the applicant for completing Form RSO-2 are contained in Appendix C.

9.2.1.2 Review of Applications

Review shall be conducted to:

- Ensure the radiological safety of the University community;
- Ensure compliance with applicable laws, regulations and licenses; and
- Facilitate the work of competent researchers.

9.2 ADMINISTRATIVE PROCEDURES

a. RSO Review

Each application shall be reviewed by the RSO who shall, within two weeks of its receipt in final form:

- Complete Section 1 Parts a, b, and c, with comments and recommendations, and forward it to the RSC; or
- Advise the applicant and the RSC Chair that review cannot be completed within two weeks, the reasons therein, and the estimated date of completion; or
- Return the application to the applicant with a request for specific revisions.

When the RSO has returned an application for revision, the applicant may:

- Make the suggested revision(s); or
- Return the application to the RSO with reasons for disagreeing with the RSO's recommendation(s).

The RSO shall then forward the application, including RSO comments and recommendations to the RSC. Unless amended by the RSC, the recommendations of the RSO shall be binding on the applicant.

b. RSC Review

In order to afford RSC members time for careful consideration and to provide timely service to applicants, the RSC shall meet to review an application not earlier than one week nor later than one month after the application (including the RSO's comments) has been distributed to committee members. (Note that ordinarily the committee will not meet during the summer months because of 9-month faculty contracts.) When RSC review cannot be completed within one month, the Chair shall advise the applicant in writing of the reasons and the estimated date of completion of the review. As a result of its review the RSC may:

- Approve the application and the recommendations of the RSO, amended as it may find appropriate; or
- Reject the application.

Upon approval by the RSC, an authorization number and expiration date shall be assigned. An acknowledgment letter containing the expiration date along with one copy of the application endorsed by the RSC Chair shall be returned to the applicant, one copy shall be provided to the RSO and one copy shall be retained in the Chair's files. If an application is rejected the record shall show the reason(s) therein, which shall be communicated by the Chair, in writing, to the applicant.

9.2.1.3 Criteria for Approval of Applications

The RSO and the RSC are concerned only with safety and regulatory compliance and not with the technical merit of the proposed use of radioactive material. Their reviews are to determine whether:

a. The applicant has the necessary training and qualifications to conduct the proposed operation safely;

b. The applicant has the necessary facilities and equipment to use the radioactive materials safely and in a manner which will comply with applicable regulations;

c. Amendment of CUA license(s) is required before commencement of the proposed operation.

9.2.1.4 Termination of Authorizations

All authorizations by the RSC shall terminate automatically at the termination date assigned, which normally will be three years from the first day of the month following approval. It is the responsibility of the Authorized User to submit a timely request for extension of ongoing programs. The RSO will maintain a tickle file to remind the user of the impending termination.

Should the Authorized User choose not to renew, he/she shall notify the RSO at least 30 days prior to the expiration (or termination) of an authorized use of radioactive material. The RSO shall ensure that the affected area and facilities are surveyed for radioactive contamination and shall advise the Authorized User and the cognizant administrator as to whether the area may be released to unrestricted use.

9.2.2 Control Of Radiation Exposure Of Individuals

9.2.2.1 Prior Occupational Exposure

A reasonable effort shall be made by the RSO to determine the prior occupational radiation exposure of each Authorized User.

9.2.2.2 Baseline Bioassay Evaluations

Individuals desiring to undertake work with radioactive materials may be required by the RSC to undergo a pre-operational baseline bioassay. Depending on the individual's exposure and work history, such tests as urine bioassay and/or controlled background body-burden may be required.

9.2.2.3 Personal Monitoring Services

Each person, who enters a posted "Radioactive Materials" area under such circumstances that he or she is likely to receive in one year an external whole body dose in excess of 500 mrem (5 mSv), shall be monitored for occupational radiation exposure as indicated below.

The RSO shall provide appropriate monitoring services and devices to Authorized Users and maintain a record of exposures and/or body burdens thus detected. The RSO and individual user shall ensure that such devices and services are properly utilized.

a. External Dosimeters

External dosimeter badges and/or rings shall be provided by the RSO to those individuals who work with or in the vicinity of sources which emit:

- beta particles with energies greater than 0.2 MeV, or
- x-rays, gamma rays or neutrons.

Dosimeters will normally be processed on a quarterly.

The use of one or more ring badge dosimeters may be required by the RSC during operations in which the dose to the hands and forearms is likely to be significantly in excess of the whole-body dose. Ring badges shall be provided by the RSO when required.

b. Bioassay

Bioassay is the determination of the kind, quantity or concentration, and location of radioactive material in the human body by direct (*in vivo*) measurement or by *in vitro* analysis of materials excreted or removed from the body. Depending on the nature of the material and the circumstances, uptake may occur by inhalation, ingestion (swallowing), skin puncture or diffusion through the skin. Bioassay may be required for pre-operational baselines and to evaluate any unusual event which causes or threatens to cause internal exposure. All suspected uptakes shall be reported immediately to the RSO, who shall provide or arrange for appropriate bioassay services.

1. Special Bioassay Requirements for Tritium

All persons who handle individual tritium sources (in any chemical or physical form other than in sealed containers) whose activity exceeds Table 1 values of NRC Regulatory Guide 8.32 shall submit urine samples to the RSO for bioassay. The frequency of bioassay shall be established by the RSO and stated in the radiation safety procedure covering work with tritium.

2. Special Bioassay Requirements for Iodine

NRC Regulatory Guide 8.20 suggests that bioassay be performed for individuals who handle unsealed quantities of I-125 or I-131 which exceed certain amounts specified under various working conditions. Bioassay services shall be performed for all individuals who handle unsealed quantities of I-125 or I-131 which exceed the Table 1 values of NRC Regulatory Guide 8.20 and at the required frequency stated in the radiation safety procedure covering work with iodine.

c. Special Precautions for Declared Pregnant Women

Authorized Users shall ensure that women, working under their jurisdiction with sources of ionizing radiation, are aware that radiation exposure may increase health risks to the fetus. A "declared pregnant woman" means a female who has voluntarily informed her supervisor, in writing, of her pregnancy and the estimated date of conception. The NRC has published a general guide on this subject which is available in the RSO office. (See also Sections 9.3.3 & 9.3.15 j(2).)

9.2.3 <u>Procurement Of Sources Of Ionizing Radiation</u>

9.2.3.1 Radioactive Material

a. Policy

Requests for procurement of any source of ionizing radiation, whether as a radiation-producing machine or as naturally occurring or artificially produced byproduct, source, or special nuclear material, shall be submitted to the RSO for approval.

The RSO shall approve such requests and transmit them to the CUA Purchasing Department (or other appropriate addressee) provided:

1. The originator has an approved authorization for the source on file with the RSO;

2. The activity requested, in the case of radioactive material, will not result in exceeding the

user's limits or the limits provided in the applicable CUA license; and

3. The Authorized User's isotope inventory on file with the RSO is current.

b. Preparation of Requisitions

Requisitions for radioactive material shall be prepared on the standard CUA requisition form. Such requisitions should not include requests for non-radioactive materials or laboratory supplies. A copy of the requisition shall be included for retention by the RSO as part of the permanent records of the office. Requisitions for radioactive material shall include the following information:

1. The words "RADIOACTIVE MATERIAL ORDER";

2. The identity of the proposed user; and

3. The symbol and mass number of each radionuclide, its chemical or physical form and the amount of activity ordered, expressed in millicuries.

9.2.3.2 Radiation-Producing Machines and Equipment

a. Definition

A radiation-producing machine is any equipment whose primary purpose is to produce ionizing radiation, or which produces ionizing radiation coincidental to its primary purpose.

b. Policy

Before acquiring any radiation-producing machine (whether by purchase, loan, consignment for evaluation, or other means), the individual who is to be primarily responsible for its use shall consult with the RSO to determine whether any special restrictions will be necessary and to acquaint himself/herself with applicable regulations.

c. Procedure

1. The responsible individual shall provide to the RSO a copy of the purchase order or other acquisition document.

2. The RSO shall be notified immediately upon receipt of a radiation-producing machine and supplied with the necessary information for registration with the government of the District of Columbia, if registration is required.

3. The RSO shall be present to survey the machine at its initial testing and at such additional testing periods as may be required to satisfactorily characterize the radiation field under all operational modes.

9.2.4 Proposals For Contracts And Grants Involving Ionizing Radiation

9.2.4.1 Investigator Responsibilities

Each proposal for or solicitation of support (of whatever form, such as a contract, grant, gift, etc.) for research which anticipates the use of radioactive material or other sources of ionizing radiation shall be submitted to the RSO for review prior to submittal to the Director of Sponsored Programs and Research Services. The purpose of the RSO review is to ensure that the proposal budget includes the cost of such radiation monitoring and protection devices and equipment as may be appropriate (if not already at hand), and to evaluate the prospective impact of the proposal on the RSO operating budget. The investigator submitting the proposal should involve the RSO sufficiently early in its preparation that agreement may be reached with respect to the required equipment and facilities. Any disagreement which cannot be resolved between the investigator and the RSO shall be referred in writing to the Chair of the RSC for resolution by the Committee, whose decision shall be binding.

9.2.4.2 RSO Responsibilities

The RSO shall endorse each proposal submitted for review to the effect that:

a. Adequate provision has (or has not) been made in the proposal budget for the cost of appropriate radiation safety measures.

b. Augmentation of the RSO budget will (or will not) be required in order to provide necessary radiation safety support services to the investigator if the contract sought is awarded. If budget augmentation is expected to be required, the RSO shall append to the endorsement a supporting budget impact analysis. A copy of the analysis shall be provided to the Chair of the RSC.

9.2.5 Receiving Shipments Of Radiation Sources

9.2.5.1 Consignment

Shipments of radioactive material intended for Authorized Users at CUA shall be delivered to:

The Catholic University of America
Radiation Safety Office
Marist Annex, Room 238
620 Michigan Avenue, NE
Washington, DC 20064

If the Radiation Safety Office is not open, radioactive material shipments will be accepted at the

The Catholic University of America
Department of Public Safety
Leahy Hall

Large shipments of radioactive material, or bulky equipment which produces ionizing radiation and/or incorporates a radioactive source, may be consigned to the user by appropriate revision of the delivery address (e.g., The Vitreous State Laboratory, Hannan Hall). However, the RSO shall be notified promptly upon receipt and before unpacking of the shipment.

9.2.5.2 Receiving

All shipments of radioactive material arriving at CUA during normal working hours shall be delivered to the RSO; carriers attempting to deliver such material which has been erroneously consigned to a department or laboratory shall be directed to the RSO. Shipments arriving outside of normal working hours shall be accepted by the Department of Public Safety. Small packages shall be physically accepted. They shall not be retained longer than necessary in the Dispatchers Office, but shall be deposited in the Radiation Safety Office by the first available campus police officer. If a package is too large or too heavy to be handled conveniently by a campus police officer, the delivering truck shall be escorted by a campus police officer to the Radiation Safety Office so that the package can be off-loaded directly.

9.2.5.3 Logging

The RSO shall maintain a log of all incoming radioactive material documenting the date of receipt, the symbol and mass number of the isotope and its chemical or physical form, the activity, the supplier, the Authorized User, and the user's receipt for the material.

9.2.5.4 Inspection

All incoming shipments of radioactive material shall be inspected by the RSO in accordance with 10 CFR 20.1906.

9.2.5.5 Delivery to Authorized User

Upon satisfactory completion of the arrival inspection, the RSO shall deliver the material or inform the Authorized User (or Departmental or Laboratory office as appropriate) of its availability for pickup. The User or designated representative shall indicate receipt of the material on the form provided by the RSO.

9.2.6 Outgoing Shipments Of Radioactive Material

No individual or organization, except the RSO, is authorized to ship or transport radioactive material from a campus location to an off-campus location.

9.2.7 Transportation Of Radioactive Material On Campus

Radioactive material may be hand-carried outside of restricted areas and between buildings on-campus, with the approval of the RSO, provided that all the following conditions are met:

a. The material is enclosed within an approved shipping container which is properly labeled;

b. The radiation exposure does not exceed either 20 mrem/hr (200 μSv/hr) at the surface of the container or 5 mrem/hr (50 μSv/hr) at a distance of one meter from the container surface;

c. There is no detectable contamination of the container's exterior surface as determined by a wipe test and survey meter measurement of the wipe test, and;

d. During transit, the radioactive material is in the continuous possession of an individual who is authorized to use or transport the material.

9.2.8 Inventory Of Sources Of Ionizing Radiation

9.2.8.1 Policy

Licenses granted the University by the NRC impose total possession limits for radioactive material by element name and mass number, and by chemical or physical form. Certain naturally occurring radioactive materials and much equipment which produces ionizing radiation are not subject to federal or local government license requirements. However, in order to ensure that the University remains in compliance with the possession limits imposed by license(s) and protects the health and safety of the University community, the RSO shall maintain a running inventory of all sources of ionizing radiation on the campus, or possessed by University Departments or Laboratories.

To provide the RSO with the information required to carry out this duty, the inventory control procedures described in the following sections shall be followed by all users of sources of ionizing radiation.

9.2.8.2 Consumable Radioactive Material

a. Definition

Consumable radioactive material is defined, for inventory control purposes, as radioactive material which is withdrawn incrementally from a stock container for user-determined end use.

b. Radioactive Material Inventory Control Number

A radioactive material inventory control number (RMIC) shall be assigned by the RSO to each container of consumable radioactive material received. The RMIC number shall be permanently affixed by the Authorized User to each stock container and shall be used in identifying the material in all inventory records. (The user may have additional identification of the material.) If the contents of the original container are partitioned into two or more stock containers, each shall have permanently affixed the RMIC number and a letter suffix.

c. Radioactive Material Inventory Control Form (RSO-1)

Form RSO-1 (Appendix B) shall be prepared in duplicate by the RSO for each container of consumable radioactive material received. The original will be used to maintain the RSO master inventory; the copy will be delivered to the Authorized User with the radioactive material. The Authorized User shall maintain the form current by recording the date, quantity and disposition of each withdrawal from the container. Upon depletion or decay of the consumable radioactive material, the completed RMIC form shall be returned to the RSO.

d. Radioactive Material Disposal Report

Interim disposal of consumable radioactive material into radwaste holding containers in the user's laboratory shall be recorded on the appropriate RMIC form (RSO-1). In addition, a running record of radioactive material deposited in each container shall be maintained. Based on these records, a Radioactive Material Disposal Report shall be prepared and shall be delivered to the RSO with each lot of radwaste. The disposal report shall show the total activity in millicuries for each radioisotope included in each container of radwaste.

9.2.8.3 Sealed Sources

Sealed radioactive sources and other radioactive material which are not intended to be consumed by incremental experimental use (such as liquid scintillation standards or other liquid reference standards) shall be recorded on a master inventory by each Department or independent Laboratory . Form RSO-3 (Appendix B) shall be used.

9.2.9 <u>Inter-User Transfer Of Radioactive Material</u>

9.2 ADMINISTRATIVE PROCEDURES

9.2.9.1 Policy

Radioactive material and radiation-producing machines shall be transferred between Authorized Users only with the prior knowledge and approval of the RSO.

9.2.9.2 Procedure

Radioactive material to be transferred shall be taken to the Radiation Safety Office where each container will be logged in, checked for external contamination, removed from the RMIC record of the former Authorized User and a RMIC form prepared for the new Authorized User in accordance with Section 9.2.8.2.

9.2.10 <u>Disposal Of Radioactive Waste</u>

9.2.10.1 Policy

No radwaste may be disposed of by conventional methods. This means, particularly, that solid radwaste may not be placed in the standard waste containers to be collected by housekeeping personnel, and that users shall not discharge radioactive waste into drains. Incineration and burial of radwaste on the CUA campus are prohibited. Radwaste contaminated only with short-lived isotopes (120 day half-life or less) will be collected by the RSO and held for decay in accordance with the provisions of applicable licenses. After a minimum 10 half-lives of decay, the waste will be surveyed to confirm the absence of detectable radioactivity, radioactive markings will be removed or obliterated, and the material will be disposed of to ordinary trash.

Radioactive material combined with or in the form of material which is hazardous, (such as toxic chemicals, biohazardous agents, etc.) shall not be disposed of without prior authorization from the RSO. The Authorized User shall advise the RSO of proposed experiments involving these or other unusual radwaste disposal problems prior to initiation of the experiments. The RSO, after consultation with the RSC and the Director of Environmental Health & Safety, shall furnish appropriate guidance to the Authorized User.

9.2.10.2 Procedure

Authorized Users shall store and dispose of radwaste only in accordance with the detailed procedures set forth in Appendix D. The RSO shall provide for removal and lawful disposition of all CUA radioactive waste. In the event that access to a licensed low-level waste site is denied, the RSO shall store radwaste in the CUA radwaste storage and handling facility until access is restored.

9.2.11 <u>Corrective Action</u>

It is anticipated that most questions of radiological safety will be resolved by consultation between an Authorized User and the RSO. To ensure that the safety of users and the public are protected, the RSO has been granted the authority to take possession of any radioactive material or suspend any procedure or operation involving the use of radioactive material or radiation producing machines which is believed to pose a radiological threat to health or property. Such action shall be reported promptly by the RSO to the RSC Chair.

9.2.11.1 Radiation Safety Committee Responsibility

The Radiation Safety Committee shall:

a. Review and confirm, modify or vitiate, for the record, all peremptory corrective action taken by the

RSO;

b. Review all allegations, by whatever party, of infractions or unsafe practices involving the possession or use of sources of ionizing radiation. The RSC may require that such allegations be placed in writing and shall respond in writing thereto;

c. Take corrective action, if required, which may include:

1. Requiring additional training of personnel prior to permitting resumption of their work under a User Authorization;
2. Alteration of the terms of a User Authorization;
3. Suspension of a User Authorization; or
4. Recommendion of administrative discipline be taken by the Vice President for Administration and Facilities Operations.

9.2.11.2 Right of Appeal

The action of the RSC may be appealed to the Associate Vice President for Facilities Operations, and ultimately to the President, by the originator of allegations brought under Section 9.2.1 or Section 9.2.11.1, or by a User in disagreement with the action of the RSC. Such appeals shall be in writing and shall set forth succinctly the factual basis for the appeal.

9.2.12 Education And Training For Radiation Safety

The RSO, the Departmental RSC representative and the Authorized User shall work together to ensure the adequacy of the radiation safety training of CUA radiation workers, as well as students whose only use of ionizing radiation may be in a closely supervised laboratory course. To assist them in sharing the University's obligation to provide radiation safety training, this section imposes certain responsibilities which partially overlap.

9.2.12.1 Responsibility of the RSO

The RSO shall ensure that the education and training of CUA radiation workers required by law, regulation, or safety considerations, is accomplished to an extent consistent with their work. To this end the RSO shall, as appropriate:

a. Supplement the prior training of applicants for authorization to use radioactive material or radiation-producing machines in order to assist them to qualify themselves for work they desire to undertake;

b. At the request of a Departmental RSC representative or Authorized User, conduct or assist in training for radiation workers;

c. Maintain records of such training conducted by the RSO, Departmental RSC representatives and Authorized Users;

d. Acquire and maintain current a collection of radiation safety related reference publications consistent with the nature and extent of the use of ionizing radiation at CUA.

9.2.12.2 Responsibility of Departmental RSC Representatives

Within each department the overall responsibility for ensuring the radiation safety education and

9.2 ADMINISTRATIVE PROCEDURES

protection of CUA personnel using, or in the proximity of the use of, sources of ionizing radiation rests with the Departmental RSC representative. He/she shall:

a. Ensure that each Authorized User within the department provides appropriate radiation safety instruction of all radiation workers for whose work and safety she/he is responsible;

b. When necessary or desirable, conduct or assist in conducting radiation safety training for departmental radiation workers;

b. Adhere to the additional instructions (as appropriate) detailed in Section 9.4;

c. Keep the RSO informed regarding the need for and the accomplishment of radiation safety training.

9.2.12.3 Responsibility of Authorized Users

Each Authorized User is directly responsible for the safe use of radioactive material and radiation-producing equipment for which he/she is responsible by all persons who may be permitted to use them. He/she shall:

a. Ensure that they have obtained the training and indoctrination required to enable safe working habits and to maintain the radiation dose to themselves and others as low as is reasonably achievable;

b. Teach those for whose radiological safety they are responsible (by instruction and example) the use of safe techniques and the application of approved radiation safety practices;

c. Enlist the assistance, as appropriate, of the RSO, the Departmental RSC representative, or others, in training their radiation workers in matters of radiation safety;

d. Maintain a record of the radiation safety training of each individual working under their authorization. The record need not include incidental instruction of students whose only use of radioactive material or radiation-producing equipment is in a regularly scheduled laboratory course under the direct supervision of appropriately trained individuals;

e. For educational or safety purposes, consider the advisability of conducting (or requiring others to conduct) experimental procedures "cold," to ensure that the procedures are sound, before they are performed with dispersible radioactive material. (The RSC may so-require by the terms of a User's Authorization.)

9.2.13 <u>Incident And Emergency Reporting</u>

9.2.13.1 Authorized User Responsibility

Each Authorized User shall notify the RSO immediately of the following types of incidents involving sources of ionizing radiation subject to his/her control:

a. Possible personnel contamination or ingestion of radioactive material;

b. Unplanned exposure to radiation;

c. Unanticipated contamination of equipment or facilities;

d. Misplacement, loss, or suspected theft of radioactive material.

Any other individual (including co-worker, subordinate or student) possessing such information shall communicate it immediately to the Authorized User, if known and available. If the responsible Authorized User is unknown or unavailable, the individual shall notify the RSO.

9.2.13.2 RSO Responsibility

The RSO shall investigate all reports of incidents involving ionizing radiation. The RSO shall inform the Chair of the RSC of any findings and recommendations. The RSO shall prepare, for the signature of the RSC Chair, any notification to the NRC or other regulatory agency, required by law or regulation concerning such incident. Prior to notifying the NRC, the RSO shall advise the least senior of the following University Officials (or their designees) who can be reached: The RSC Chair, the Associate Vice President for Facilities Operations or the President. If none of these individuals can be contacted, the RSO shall make the required notification, take charge of the emergency situation which required the notice and inform the indicated University officials as soon as practicable.

9.3 RULES FOR CONTROL AND MONITORING OF PERSONNEL EXPOSURE AND ENVIRONMENTAL RADIATION

9.3 RULES FOR CONTROL AND MONITORING OF PERSONNEL EXPOSURE AND ENVIRONMENTAL RADIATION

This chapter sets forth rules which are intended to assist Authorized and Individual Users in conducting their work safely, in compliance with applicable regulations, and in a manner which will ensure that exposures to ionizing radiation are maintained as low as is reasonably achievable (ALARA). These rules are an implied part of each User's Authorization granted by the RSC.

9.3.1 Access Control

Access control serves two important purposes. The first is to protect the public by ensuring that the total effective dose equivalent to individual members of the public from licensed operations does not exceed 100 mrem (1 mSv) in a year. The second purpose of access control is to provide for the physical security of licensed radioactive materials. Definitions for the access control terms that follow: unrestricted area, controlled area, and restricted area are quoted from Federal regulations (10 CFR Part 20, Standards for Protection Against Radiation).

9.3.1.1 Unrestricted Area

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

No member of the public shall receive a dose exceeding 2 mrem (20 μSv in any one hour, nor shall radioactive material be used or stored in an unrestricted area in quantities that (per isotope) exceed those specified in Appendix C of 10 CFR Part 20 (attached as Appendix E to this Manual). Licensed materials stored in an unrestricted area shall be secured from unauthorized removal or access. Constant surveillance shall be maintained over any licensed material in use (i.e., not in storage) in an unrestricted area.

9.3.1.2 Controlled Area

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

If an area contains radioactive material exceeding the quantity specified per isotope in Appendix C of 10 CFR Part 20, it shall be designated a "controlled area" and shall be posted in accordance with Section 9.3.2 of this manual. Access shall be controlled by the responsible Authorized User to ensure that:

- the total effective dose equivalent to an individual member of the public from licensed operations does not exceed 100 mrem (1 mSv) in a year;
- occupational exposures are maintained as low as is reasonably achievable (ALARA);
- licensed materials are secure from unauthorized removal or access ; and
- constant surveillance is maintained of licensed materials not in storage.

9.3.1.3 Restricted Area

Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to ionizing radiation or radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

9.3 RULES FOR CONTROL AND MONITORING OF PERSONNEL EXPOSURE AND ENVIRONMENTAL RADIATION

NOTE: It is CUA policy that radioactive materials will not be used or stored in residential buildings.

When an area contains radiation exposure levels ≥2 mrem/hr (≥20 µSv/hr) or contains radioactive material exceeding 10 times the quantity specified per isotope in Appendix C of 10 CFR Part 20, it shall be designated a "restricted area"; it shall be posted in accordance with Section 9.3.2, and access shall be controlled by the responsible Authorized User to ensure that:

- access is limited to authorized personnel equipped with appropriate personal dosimetry;
- visitors are escorted by an authorized individual, are equipped with personal dosimetry; and
- the total effective dose equivalent to any visitor from licensed operations does not exceed 100 mrem (1 mSv) in a year.

More than one of the sub-classifications defined below may be applicable to a restricted area.

"RADIATION AREA" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem (50 µSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

"HIGH RADIATION AREA" means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 100 mrem (1 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

"AIRBORNE RADIOACTIVITY AREA" means a room, enclosure or area in which airborne radioactive materials, composed wholly or partly of licensed material, exists in concentrations:

(1) In excess of the derived air concentrations (DACs) specified in Appendix B to 20 CFR 20.001-20.2401, or

(2) To such a degree that an individual present in the area without respiratory protective equipment could exceed, during the hours an individual is present in a week, an intake of 0.6 percent of the annual limit on intake (ALI) or 12 DAC-hours.

No practice or procedure having the potential to create a high radiation area or airborne radioactivity area shall be performed at CUA without written approval from the RSC.

9.3.2 Posting Of Controlled and Restricted Areas

The RSO shall furnish, and the responsible Authorized User shall post at each entrance to a controlled or restricted area a sign bearing the radiation caution symbol, the word "CAUTION" and one or more of the following wordings as appropriate, "RADIOACTIVE MATERIAL" "RADIATION AREA", or "HIGH RADIATION AREA".

For a controlled area (i.e., radioactive material present in quantity exceeding that specified in Appendix C of 10 CFR Part 20) the words "RADIOACTIVE MATERIAL" shall be included on the sign(s).

Postings for restricted areas shall at a minimum include the words "RADIOACTIVE MATERIAL" on the sign(s). Restricted areas with radiation exposure levels ≥5 mrem/hr (≥50 µSv/hr) shall additionally include the words "RADIATION AREA" or, if the radiation exposure level is ≥100 mrem/hr (≥ 1 mSv/hr), the words "HIGH RADIATION AREA".

The name and telephone numbers (office and residence) of the Authorized User responsible for a controlled or restricted area shall also be included on or adjacent to each posting required by this section.

9.3.3 Occupational Dose Limits

Federal regulations (10 CFR 20, Subpart C, Section 20.1201) limit the occupational dose for an adult (18 years of age or older) to an annual total effective dose equivalent (TEDE) of 5 rems (50 mSv). This total effective dose equivalent is the sum of both external and internal exposure to the whole body (defined to include the head, trunk, gonads, arms above the elbow, and legs above the knee). The regulations further state that the annual occupational dose limit for a minor is 10% of the adult limit or, 500 mrem (5 mSv). Similarly, 500 mrem (5 mSv) is also the federal dose limit to an embryo/fetus during a declared pregnant woman's entire pregnancy.

Annual limits are also established by the NRC for exposure to the lens of the eye, to the skin, and to the extremities (defined as the hands, elbows, arms below the elbow, feet, knees, and legs below the knee). These limits are: an eye dose equivalent of 15 rems (0.15 Sv) and a shallow-dose equivalent of 50 rems (0.5 Sv) to the skin or any extremity.

To maintain CUA personnel exposures ALARA and ensure compliance with federal limits, the annual CUA occupational ALARA goal for all individuals (minors, adults and declared pregnant women) shall be 500 mrem (5 mSv) TEDE. Furthermore, the CUA occupational ALARA goals for dose to the lens of the eye, skin, and extremities shall be 10% of the applicable federal limits. Table 9.3.3 presents the federal dose limits and CUA occupational ALARA goals herein described (expressed in both millirem and milliSeiverts).

Table 9.3.3
Occupational dose levels

ORGAN	10 CFR 20 Annual Limit mrem (mSv)	CUA ALARA Goal mrem (mSv)
Total Effective Dose Equivalent:		
-for an adult individual-	5,000 (50)	500 (5)
-for a minor-	500 (5)	500 (5)
-for a declared pregnant woman-	500 (5)	500 (5)
Eye dose equivalent:	15,000 (150)	1,500 (15)
Shallow dose equivalent to the skin or to any extremity:	50,000 (500)	5,000 (50)

Each individual shall be responsible for ensuring that his/her occupational exposure is maintained ALARA. Each Authorized User shall control operations so that no individual working in a controlled or restricted area receives from sources in the possession of CUA an occupational dose equivalent that exceeds the ALARA goals established herein. Should any CUA employee receive a dose exceeding an ALARA goal, the RSO will perform an investigation and document relevant findings.

9.3.3.1 External Exposure

External exposure means that portion of the dose equivalent received from radiation sources outside the body and is measured by personal dosimeter (i.e., a film badge and/or thermoluminescent dosimeter). Individuals shall maintain their external exposure ALARA through appropriate application of the Time, Distance, and Shielding principles. To wit:

- a reduction in the time spent in the presence of radioactive material will reduce the dose received from that material;
- an increase in distance from a source of radioactivity will reduce the dose rate by the inverse of the square of the distance from that source (i.e., doubling the distance decreases the dose rate by a factor of four, trebling the distance decreases the exposure rate by a factor of nine, etc);
- an increase in the amount of shielding between the individual and the source will reduce the exposure received from the source.

If an individual receives a quarterly external exposure in excess of 125 mrem (1250 μSv) limit, an investigation shall be conducted by the RSO and responsible Authorized User to determine the cause.

9.3.3.2 Internal Exposure

Internal exposure means that portion of the dose equivalent received from radioactive material taken into the body and is measured through bioassay (i.e., in vivo body counting and/or in vitro assay of urine and/or fecal samples). Internal exposure results from injection, ingestion, or inhalation of radioactive material. It shall be controlled by following sound laboratory practices (Section 9.3.17), and by limiting airborne and surface contamination (Sections 9.3.3.3 and 9.3.3.4, respectively).

9.3.3.3 Airborne Contamination Limits

Federal regulations have established airborne radioactivity concentration limits to prevent overexposure of any organ in the body as a result of breathing contaminated air. These limits are specified in 10 CFR 20, Appendix B, Table 1. The table lists, by isotope, an annual limit on intake (ALI) and the derived air concentration (DAC - that concentration which, if breathed for 2,000 hours, would result in inhalation of one ALI). If more than one isotope is airborne, the sum of fractions rule applies.

9.3.3.4 Surface Contamination Limits

Surface contamination limits for unrestricted, controlled, and restricted areas on the CUA campus are given in Table 9.3.3.4 (from NRC Regulatory Guide 8.23). These limits are subject to the following conditions and interpretations:

a. The tabulated limits are to be used as a guide and, in practice, professional judgment shall be used by the RSO to determine the acceptability of the actual contamination.

b. Although it is believed that the recommended limits would not result in a health hazard, good radiation protection practice dictates that contamination levels should be kept ALARA.

Table 9.3.3.4

Removable surface contamination limits on the CUA campus

Type of surface	Alpha emitters	Beta emitters

	(dpm/100 cm^2)	(dpm/100 cm^2)
Unrestricted and Controlled areas	22	220
Restricted areas	220	2,200
Protective clothing worn only in restricted areas	220	2,200

9.3.4 Personnel Monitoring

Personnel dosimeters will be provided to persons authorized to work with radioactive materials at the discretion of the RSO. The dosimeters will be obtained from NVLAP approved dosimetry vendor. It shall be the responsibility of each individual to wear the prescribed personnel monitoring devices during all work with sources of ionizing radiation and to ensure that samples for bioassay are submitted when requested by the RSO.

9.3.4.1 Request for Issue of Personal Dosimetry

Upon assignment of duties which will require work with sources of ionizing radiation, CUA personnel not currently equipped with dosimetry may complete and submit to the RSO a "Request for Issue of Personal Dosimetry" on form RSO-6 (Appendix B). Should the RSO determine that dose monitoring is approporiate, authorization to perform such work shall not be granted until the worker is in possession of personal dosimetry.

9.3.4.2 Prior Occupational Dose

Personnel issued dosimetry at CUA shall either provide or assist the RSO in obtaining, records of occupational exposure received at other facilities. Individuals having worked with licensed or registered sources of radiation at other facilities but not in possession of current exposure records shall complete and submit form RSO-7 "Request for Occupational Exposure Records" (Appendix B). Individuals who have not been subject to occupational dose monitoring shall provide a written statement to that effect on the same form.

9.3.4.3 Temporary Personnel and Visitor Dosimetry

. Temporary personnel assigned radiological work for periods of one calendar quarter or less and visitors requiring escort into a restricted area at CUA shall be issued one of the numbered visitor dosimeters stored with the Visitor Film Badge Logbook. At the time of issue, the person receiving the dosimeter shall ensure that the following required information is legibly entered into the logbook:

- the temporarily assigned person's or visitor's full name;
- Social Security number;
- date of birth;
- current mailing address;
- date that dosimetry was issued; and
- escort's name.

9.3.5 Surveys

9.3.5.1 Definitions

"Survey" is defined to mean measurement of levels of radiation exposure (dose rate) or concentrations of radioactive materials present in uncontrolled form and disposition (contamination).

"Unsealed container" is defined to mean any container of radioactive material which is open to the atmosphere or which can be opened.

9.3.5.2 Authorized User Responsibility for Surveys

The responsible Authorized User shall ensure that each room in which unsealed containers of radioactive material totaling in excess of 1 millicurie are used or stored is surveyed at least weekly, and daily when procedures using unsealed sources in excess of 1 mCi are performed. Wipe tests shall be used for carbon-14 and tritium. (Clean wipes are available from the RSO.) The results of User surveys shall be recorded in a suitable chronological log for each affected area, which shall indicate the areas surveyed, the level of removable contamination measured (dpm/100 cm^2) and the isotope most likely to be present.

9.3.5.3 RSO Responsibility for Surveys

The RSO shall ensure that wipe tests and/or meter surveys, independent of those conducted by Users, are performed in all CUA controlled and restricted areas once per month. Special projects or campaigns may be monitored more frequently. The results of these surveys shall be made a permanent part of the records of the RSO.

9.3.5.4 Requirement for Decontamination Efforts

When a meter survey indicates a radiation exposure rate greater than twice background, in the absence of known sources, that area shall be considered contaminated and a wipe test shall be made to determine the extent of the removable contamination. Decontamination efforts shall be undertaken when removable activity is found to exceed 50% of the limits stated in Table 9.3.3.4; good practice dictates that decontamination efforts should be undertaken as soon as practicable whenever removable contamination is demonstrated to be present.

9.3.6 Survey Instruments

9.3.6.1 Procurement

In conjunction with Section 9.2.4.1, the RSO shall assure that appropriate survey instrumentation is available to each laboratory in which radioactive materials, other than tritium, are used.

9.3.6.2 Calibration

Survey instruments shall be calibrated at least annually. Each meter calibrated shall bear a label indicating the date of last calibration, the date calibration is next due, and any conversion factors. The RSO shall provide or arrange for calibration service.

9.3.6.3 Repair

The RSO is responsible for maintenance and repair of all CUA-owned radiation protection instruments.

9.3.7 Labeling Containers Of Radioactive Material

9.3.7.1 Requirements

Each container of radioactive material shall bear a durable, clearly visible label bearing the radiation caution symbol, the words "CAUTION RADIOACTIVE MATERIAL", and where it is necessary to avoid or minimize exposure, sufficient information such as radionuclide present, quantity, radiation levels and date. In addition, the RMIC number shall be affixed in accordance with Section 9.2.8.2.b.

Appropriate labels will be supplied by the RSO.

9.3.7.2 Exceptions

The RSO will advise when certain exceptions to the labeling requirement may be appropriate.

9.3.8 Storage Of Radioactive Material

Licensed material shall be stored only in controlled or restricted areas and in a manner which provides adequate protection against fire, explosion, flooding or unauthorized removal. Such radioactive material shall be stored in suitable containers and direct radiation (beta/gamma) from the container shall be limited by shielding in accordance with Section 9.3.9.

9.3.9 Shielding Sources Of Ionizing Radiation

All sources of ionizing radiation, including stock materials, in a restricted area shall be shielded so that the dose rate shall not exceed 10 mrem/hr (100 μSv/hr) at any exposed surface of the container or shield, or 5 mrem/hr (50 μSv/hr) at 30 centimeters from any exposed surface of the container or shield. The exposure rate in the nearest unrestricted area accessible to personnel shall not exceed 0.5 mrem/hr (5 μSv/hr).

9.3.10 Radioactive Waste

Radwaste shall be stored and disposed of only in accordance with the detailed procedures set forth in Appendix D of this manual.

9.3.11 Misplacement, Loss, Or Theft Of Radioactive Material

Discovery of the misplacement, loss, or theft of radioactive material shall be reported promptly to the RSO, who shall be guided by applicable regulations in notifying appropriate authorities.

9.3.12 Equipment Used For Radioactive Work

9.3.12.1 Removal of Equipment from Controlled or Restricted Areas

Equipment which has been used with radioactive material, or which may have become contaminated by radioactive material, shall not be removed from a controlled or restricted area to an unrestricted area (e.g., repair shop, machine shop, other laboratory, cleaning facility or returned to vendor) until demonstrated to be free of contamination in accordance with Table 9.3.12.1.

Table 9.3.12.1
Surface contamination limits for unrestricted release of equipment

	Average	Maximum	Removable

Nuclide	(dpm/100 cm^2)	(dpm/100 cm^2)	(dpm/100 cm^2)
U-nat, U-235, and associated decay products	5,000	15,000	1,000
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000	15,000	1,000

9.3.12.2 Repair of Contaminated Equipment

Equipment to be repaired or modified on site in a restricted area by University or contractor personnel shall be decontaminated, if practicable, prior to servicing. If decontamination to the levels prescribed in Table 9.3.12.1 is not practicable and the repair or modification is warranted by the value of the equipment, the work shall be directly supervised by the Authorized User and/or RSO who shall ensure that appropriate precautions are taken for the radiological safety of CUA personnel.

9.3.12.3 Vacuum Systems

Vacuum lines which are built into fume hoods or which discharge into a central vacuum system shall not be used for procedures in which radioactive material could be drawn into the line. A separate vacuum pump exhausting into a fume hood which has been approved for use with radioactive materials shall be used instead; a pump exhaust filter may be required. A pump, once so-used, shall be considered contaminated, and so-labeled, until demonstrated otherwise.

9.3.13 Radiation-Producing Machines and Equipment

Radiation-producing machines (RPM) and radiation producing equipment (RPE) are defined as any machine or equipment whose primary purpose is to produce ionizing radiation, or which produces ionizing radiation coincidental to its primary purpose. Exposure from RPM and RPE must not exceed a dose equivalent in excess of 5 mrem (0.05 mSv) in one hour at 5 centimeters from any surface of the machine or equipment.

9.3.13.1 Exemption from Regulation

Equipment is not subject to these rules if the production of ionizing radiation is not a primary purpose and the exposure does not exceed 0.5 mrem/hr (5 μSv/hr) at 5 centimeters from any accessible surface.

9.3.13.2 RSO Responsibility and Authority

The RSO shall be permitted access to radiation-producing equipment for the purpose of inspection and survey. The RSO shall:

a. Survey each RPM at its initial testing and at subsequent intervals not to exceed one year. Annual re-survey is not required if the machine is not in use, but a survey shall be conducted at the first resumption of operation.

b. Establish safety restrictions on the use of each RPM for the protection of operating personnel and the public. (Should the principal Authorized User believe that RSO-established restrictions are too strict, a review by the RSC may be requested; the written request shall be addressed to the RSC Chair).

c. Conduct an orientation lecture concerning the hazards and safety precautions associated with the use of each type of RPM which shall be attended by each individual authorized to operate the equipment without direct supervision.

d. Halt the use of any RPM should operation pose an unreasonable radiation hazard.

e. Report to the RSC any violation of safety restrictions or general safety rules specified in Section 9.3.13.3.

9.3.13.3 General Safety Rules for RPE

Radiation-producing equipment (RPE) shall be operated only by designated personnel. Designated personnel are defined as "Principal Users" or "technicians". Qualifications of Principal Users shall be submitted to the RSC for approval on Form RSO-4 "Qualifications of Principal Users of Radiation-Producing Machines" (Appendix B). Qualifications of technicians shall be evaluated and approved by a Principal User and written notification of this qualification shall be on file with the RSC and the RSO. Technicians shall operate radiation-producing machines under the supervision of a Principal User. Students and others who use RPE as part of a regularly scheduled course or on a very infrequent basis are exempt from the requirement of registration with the RSC, provided that such operation is conducted under the direct supervision of a Principal User. All RPE shall be operated in accordance with the following provisions:

a. Areas in which RPE is located or is being used shall be posted with the characteristic "Caution (or Danger) Radiation" or "Caution (or Danger) X-rays" sign to warn unauthorized personnel from entering the controlled area. The controls for each RPM shall have a decal stating "Caution (or Danger) Radiation - This Machine Produces Radiation When Energized." In certain instances, other precautions such as locking room entrances, locking the machine controls, or the use of automatic safety devices may be required by the RSC.

b. Radiation-producing equipment shall not be operated without the presence of the RSO if it has not been operated for more than one year.

c. Portable radiation-producing machines shall not be operated at locations outside the laboratory where the machine has been surveyed without the prior approval of the RSO.

d. When not in use, each radiation-producing machine shall be either disconnected from its power source or locked to preclude operation by unauthorized personnel.

e. Before operating the machine the operator shall clear the area in the direction of the primary beam of all personnel.

f. Personnel monitoring devices shall be worn by the operator and all others present during operation of any machine which is capable of creating an exposure field in excess of 2 mrem/hr (20μSv/hr) at any accessible location.

g. The operator shall never expose any person to the direct beam of the machine and must not enter an exposure or target room while a machine is in operation unless adequately shielded.

h. All incidents involving radiation levels in excess of those authorized or anticipated, or possible exposures of personnel, shall be reported immediately to the RSO.

i. A primary beam shall not be directed towards an interior wall, ceiling or floor in the absence of approved primary beam shielding.

j. The structural shielding requirements for any new installation or for an existing installation must be approved by the RSC.

k. All operating personnel shall observe all restrictions, established by the RSO or RSC, on the use of RPE. They shall bring to the attention of the RSO discovery of a potentially hazardous mode of operation which has not been anticipated by such restrictions.

9.3.14 Use Of Radioactive Material In Animals

a. Radioactive material shall not be used in experimental animals without the approval of the RSC. The RSO shall also be advised before starting work.

b. The use of animals for experimental purposes shall be consistent with current Department of Health and Human Services guidelines.

9.3.15 Responsibilities Of Authorized Users

With respect to radiological safety, the primary responsibility of Authorized Users is to ensure that radiation exposure to themselves, to individual users for whom they have radiological safety oversight, and to the public, is maintained both within the limits prescribed in this manual, and as low as is reasonably achievable (ALARA). To this end they shall:

a. Be familiar with, comply with, and require compliance by others with, the instructions in this manual and their authorizations for use of sources of ionizing radiation.

b. Plan adequately for experiments and emergencies, consulting the RSO when appropriate.

c. Teach (by instruction and example) those for whose radiological safety they have oversight the use of safe techniques and the application of approved radiation safety practices (the RSO will conduct or assist in such instruction on request).

d. Ensure that appropriate radiation survey and monitoring equipment is available and used, and that it is functional and calibrated when due.

e. Ensure that appropriate protective equipment (e.g., shielding, exhaust hoods and filters, glove boxes, etc.) is available and properly used and maintained.

f. Maintain a current record of the receipt and disposition of radioactive material charged to them.

g. Limit the use of radioactive material and sources of ionizing radiation for which they are responsible, to individuals over whom they have supervisory control and to locations specified in their User Authorizations, and ensure that no unauthorized use is made thereof.

h. Allow only authorized persons to enter rooms specified as restricted areas.

i. Inform the RSO immediately if any of the following circumstances are suspected:

   1. Any incident that causes or threatens to cause exposure to a member of the public.

   2. Inhalation, ingestion or injection of radioactive material by any person.

   3. Accidental spill of radioactive material, or release of radioactive material to the atmosphere, drain, or ventilation system.

j. Inform the RSO, in a timely manner, when:

   1. It becomes necessary to delegate radiation safety responsibilities to another qualified individual (i.e., due to a protracted absence from the University).

   2. The Authorized User or a radiation worker under the Authorized User's supervision has declared she is pregnant.

   3. Changes are anticipated in the work under the Authorized User's supervision which may increase the probability or extent of exposure to ionizing radiation.

   4. Changes are anticipated in personnel working with sources of ionizing radiation.

k. Provide notification to the RSO of any changes regarding rooms in which radioactive material is stored or used, or in which radiation-producing equipment is used.

l. Provide an up-to-date list to the RSO of personnel who may be handling radioactive material. Students whose only handling of radioactive material occur incidental to a regularly scheduled class need not be individually named on the required list.

9.3.16 Responsibilities Of Individual Users

"Individual User" is defined to mean any person who works with sources of ionizing radiation under the supervision of an Authorized User.

Individual Users shall conduct their operations so as to maintain the radiation exposure of themselves and others as low as is reasonably achievable (ALARA). To this end they shall:

a. Understand and comply with the work habits prescribed in Section 9.3.17 and the instructions received from the Authorized User to whom they are responsible.

b. Wear prescribed personnel monitoring equipment and protective clothing during all work with or in the vicinity of sources of ionizing radiation.

c. Consult the Authorized User to whom they are responsible BEFORE PROCEEDING if they have any doubt about the correctness or safety of an intended procedure.

d. Inform the responsible Authorized User and/or the RSO immediately if any of the following circumstances is known or suspected:

   1. Any incident that causes or threatens to cause exposure to a member of the public.

   2. Inhalation, ingestion or injection of radioactive material by any person.

   3. Accidental spill of radioactive material or release of radioactive material to the atmosphere, drain, or ventilation system.

e. Keep accurate records of the use and disposal of radioactive material transferred to them.

f. Make no unauthorized use, transfer, or disposition of radioactive material.

9.3.17 <u>Work Habits</u>

9.3.17.1 Preparatory

Before any work is undertaken with radioactive material, attention shall be given to precautionary measures, including the use and adequacy of hoods, filters, and remote handling equipment. The RSO shall be consulted on specific operations which could deviate from previously authorized procedures.

9.3.17.2 Protective Clothing

Suitable gloves shall be worn during all work with unsealed radioactive material. Dispose of gloves to radwaste after use. Protective glasses or goggles shall be worn if there is a possibility of contamination of the eyes.

INDIVIDUALS WITH OPEN SORES/CUTS ON THEIR HANDS, WITH OR WITHOUT BANDAGES, ARE NOT AUTHORIZED TO WORK WITH UNSEALED RADIOACTIVE MATERIALS

Additional protective clothing, such as laboratory coats, coveralls, rubber aprons, and shoe covers, shall be worn whenever contamination of clothing with radioactive material is possible, as appropriate. Protective clothing shall not be worn or taken out of the local areas in which its use is required unless surveyed and found to be free of contamination. Under no conditions may protective clothing be worn in eating places.

9.3.17.3 Materials Handling

a. Prior to performing an operation on or with a source of ionizing radiation, radiation levels shall be measured. Remote handling tools, such as forceps and tongs, shall be used for handling a source which causes an exposure, at contact, in excess of 50 mrem/hr (500 μSv/hr).

b. When working with a source of ionizing radiation which emits penetrating radiation of sufficient intensity to produce significant exposure, a survey meter shall be used to monitor work in progress to confirm the adequacy of shielding or remote handling tools.

c. Approved exhaust ventilation shall be used when performing operations which might produce airborne contamination (e.g., evaporation, sanding or grinding, transfers of unsealed powder or volatile radioactive material, etc.). Approved exhaust ventilation means a hood, glove box, or local exhaust facility which has been approved for work with radioactive materials. Approved facilities shall be so-designated by printed labels attached to the ventilation unit.

d. Work which can result in contamination of work surfaces shall be done in trays. The choice of tray material will depend on the chemicals to be handled and the ease of decontamination versus disposable trays. Adjacent work surfaces shall be lined with absorbent paper.

e. Work areas shall be kept clean and free of equipment and materials not required for the procedures in progress.

f. Unsealed radioactive material shall be stored in shatterproof plastic containers when practicable. Additional precautions such as the use of carts or shatterproof protective outer containers shall be taken when transporting glass containers.

g. Contaminated equipment and tools (glassware, hot plates, stirrers, hand tools, etc.) shall be appropriately identified and isolated from other equipment if it is to be retained for future use. Once used for radioactive work, such material shall not be removed from a controlled or restricted area until demonstrated to be free of contamination in accordance with Section 9.3.12.1, unless it is packaged and removed as radwaste.

h. In order to minimize the risk of contaminating wounds, special care shall be exercised when assembling, disassembling and manipulating contaminated glassware.

9.3.17.4 Hygiene

a. MOUTH PIPETTING OF ANY MATERIAL IS FORBIDDEN. Always use pipetting equipment.

b. Do not eat, drink or store food in rooms where radioisotopes are used or where contamination may exist.

c. Smoking is prohibited in all laboratory areas.

d. Personnel working with radioactive material should wash hands before eating, smoking, or leaving work; they shall make hand and shoe surveys, when appropriate, prior to leaving a controlled or restricted area where operations with unsealed sources are conducted.

e. Food, drink and photographic film shall not be stored in a refrigerator used for storage of radioactive material.

f. Keep fingernails trimmed to minimize the likelihood of puncturing protective gloves.

g. In the course of working with unsealed radioactive material, if personal contamination is suspected, stop work and survey with a suitable instrument. This shall be followed by any required decontamination and a further survey.

IF CONTAMINATION IS SUSPECTED OR CONFIRMED, DO NOT LEAVE THE AREA.

9.3 RULES FOR CONTROL AND MONITORING OF PERSONNEL EXPOSURE AND ENVIRONMENTAL RADIATION

NOTIFY YOUR AUTHORIZED USER, THE RSO, OR THE DEPARTMENT OF ENVIRONMENTAL HEALTH AND SAFETY.

9.4 SPECIAL INSTRUCTIONS FOR UNIVERSITY STAFF DEPARTMENTS

9.4 SPECIAL INSTRUCTIONS FOR UNIVERSITY STAFF DEPARTMENTS

Radiation precaution signs and labels apply to all personnel. They do not mean that a hazard exists unless it is explicitly so-stated; they do mean that a hazard could exist if inappropriate action were taken. Most frequently these signs mean that radioactive materials are present in shielded containers. These containers, which may be of metal, glass or plastic (depending on the type of radioactive material contained), are individually labeled and should not be touched or moved by staff personnel who must perform work in a restricted area. All working areas of these rooms are checked frequently for radioactive contamination and are safe for work by cleaning, maintenance or public safety personnel.

9.4.1 <u>Housekeeping</u>

The Director of Facilities Maintenance & Operations shall ensure that all housekeeping personnel (whether University or contractor employees) assigned to work in Hannan, Maloney, McCort-Ward and Nursing-Biology attend an initial RSO lecture on elementary radiation safety as part of their indoctrination for employment at CUA, and receive refresher training on an annual basis. Attendees shall demonstrate knowledge and understanding of the following minimum rules which have been established for their safety:

a. Housekeeping personnel shall not do any work inside a fume hood or glove box which bears a radiation warning sign; and

b. Housekeeping personnel shall remain outside any area within a laboratory which is roped off with a yellow and magenta radiation warning rope.

c. Housekeeping personnel shall not dispose of packages, or empty waste containers, that bear radioactive material labels.

9.4.2 <u>Maintenance</u>

The Director of Facilities Maintenance & Operations shall ensure that all maintenance personnel (whether University or contractor employees) assigned to work in Hannan, Maloney, McCort-Ward and Nursing-Biology attend an initial RSO lecture on elementary radiation safety as part of their indoctrination for employment at CUA, and receive refresher training on an annual basis. Additionally, the Director of Maintenance shall obtain prior clearance from the Radiation Safety Officer before permitting maintenance work to proceed on the following types of facilities:

a. Fume hoods bearing a radiation warning sign;

b. Ducts and blowers which service fume hoods bearing a radiation warning sign;

c. Pits or sumps in the sewer system for Hannan, Maloney, McCort-Ward and Pangborn Halls;

d. Any facilities in the Radioactive Materials Storage Area; or

e. Any other facility where there is any question as to the possible presence of radioactive contamination.

In working within restricted areas, maintenance personnel shall remain outside any area which is roped off with a yellow and magenta radiation warning rope, unless accompanied by the Authorized User who is responsible for the area, or by the Radiation Safety Officer.

9.4 SPECIAL INSTRUCTIONS FOR UNIVERSITY STAFF DEPARTMENTS

9.4.3 Public Safety

The Director of Public Safety shall ensure that:

a. All newly-hired Campus Police Officers attend an initial RSO lecture on elementary radiation safety as part of their indoctrination for employment at CUA, and receive refresher training on an annual basis.

b. All Campus Police Officers attend an annual refresher lecture on radiation safety.

c. Public Safety guards who find a restricted area open and unattended shall:

   1. Close and lock the room; and

   2. Report the matter to the Dispatcher.

d. The Department of Public Safety shall notify the cognizant Department Chair and the RSO, on the next regular working day, of the date, time and location of the action taken under subparagraph 9.4.3.c.

9.4.4 Purchasing

The Director of Purchasing shall ensure that:

a. A purchase order is not prepared (nor a purchase order number provided for an order placed by telephone) for any radioactive material unless the requisition has been approved by the Radiation Safety Officer. If in doubt, the originator of the requisition, or the Radiation Safety Officer, shall be asked if the material being ordered is radioactive.

b. All purchase orders for radioactive material shall show the delivery address as:

   The Catholic University of America
   Radiation Safety Office
   Marist Annex, Room 238
   620 Michigan Avenue, NE
   Washington, DC 20064

   In addition, purchase orders must be accompanied by instructions stating that if the Radiation Safety Office is not open at the time of delivery, packages of radioactive materials shall be delivered to the Department of Public Safety in Leahy Hall.

9.4.5 Sponsored Programs And Research Services

The Assistant Academic Vice President for Sponsored Programs and Research Services shall ensure that each proposal for or solicitation of support for research, which indicates that the use of radioactive material or other sources of ionizing radiation (such as X-ray or X-ray diffraction machines) is intended in the course of the proposed research, has been reviewed and endorsed by the University Radiation Safety Officer before it is released to the addressee. The endorsement of the Radiation Safety Officer is solely for University internal purposes and should not accompany the proposal when it leaves the University.

9.5 EMERGENCY PROCEDURES

9.5.1 Introduction

9.5 EMERGENCY PROCEDURES

For the purpose of this manual, an emergency is defined as any incident resulting from the use of one or more sources of ionizing radiation which creates an internal or external hazard to personnel. The primary purpose of a planned response to a radiation emergency is (a) to minimize internal contamination by radioactive material due to ingestion, inhalation, absorption or entry through wounds, (b) to hold exposure to external ionizing radiation to the lowest possible level, and (c) to provide appropriate first aid or medical care on a basis consistent with (a) and (b).

An emergency may vary in magnitude from an apparently insignificant spill of low-level radioactivity to a fire or explosion involving hazardous quantities of radioisotopes. The following steps are applicable to responding to all emergencies. Detailed suggestions for handling specific types of emergencies are given in Section 9.5.4; they should be modified by each Authorized User to meet the specific requirements of each restricted area for which he/she is responsible.

a. Evaluate the situation in regard to levels of external radiation exposure and the risk of contamination by radioactive material. If a situation develops where an emergency involving radioactivity also has a potential for producing other serious hazards, e.g., flammable or toxic fume accumulations, consider all hazard potentials and act accordingly.

b. If external radiation levels are high, evacuate personnel from the accident area. If the possibility exists that personnel are contaminated, confine their movement until they have been monitored.

c. The quantities of radioactive materials approved for use by Authorized Users at CUA are low enough that medical attention for serious injuries should always take precedence over decontamination procedures.

d. Obtain RSO and other appropriate assistance promptly.

e. Give first aid if needed. Monitor all persons who may be contaminated. Perform simple decontamination, if necessary, and re-monitor.

f. Obtain a careful history of the accident.

9.5.2 Authorized User Responsibility

The Authorized User is primarily responsible for preparing himself/herself and those for whose work he/she is responsible to respond promptly and correctly to emergencies. Each Authorized User shall:

a. Ensure that all personnel authorized to work in the affected areas are familiar with the emergency response procedures described in Section 9.5.

d. Prepare a complete written history of each emergency and subsequent related activity, including corrective and preventive actions. This report shall be delivered to the RSO within 15 days of the emergency.

9.5.3 Emergency Notification

Authorized Users of sources of ionizing radiation on the CUA campus are required (by Section 9.3.2) to post at the entrance to each restricted area the name and telephone number(s) of the individuals to be contacted in case of an emergency.
The CUA Radiation Safety Officer may be reached on extension 5206. Call Public Safety at extension 5111 for all events requiring emergency assistance.

9.5.4 Procedures For Specific Types Of Emergencies

9.5 EMERGENCY PROCEDURES

9.5.4.1 Airborne Contamination: Radioactive dust, mist, fumes, gases, vapors

a. **EVACUATE** all personnel from the building immediately.

To the extent possible as you leave the area, close windows and turn off window air conditioning units. Turn ON all hood blowers.

Leave the room promptly.

Close and lock the door to preclude unauthorized entry.

b. **HOLD** all personnel involved immediately outside the room and instruct them to stay in one location to prevent the spread of contamination.

c. **ISOLATE** the adjacent corridor against traffic and spectators.

d. **NOTIFY** the RSO; hold personnel for RSO's arrival, and assist in evaluating hazards, determining re-entry times, and monitoring for personnel contamination.

9.5.4.2 Contaminated Personnel - Without Injury

a. External Contamination: See Section 9.5.5, Decontamination.

b. Internal Contamination: See Section 9.2.2.3.b.

9.5.4.3 Contaminated Personnel with Serious Injury

a. Immediate Action

Should any injury require off-campus hospital and medical assistance call Public Safety (5111) and request activation of the Washington, D.C. Emergency Action Response Plan. Provide minimum decontamination while awaiting ambulance response. Minimum decontamination is accomplished by cutting off or removing patient's outer clothing and putting on clean coveralls or lab coat. If this cannot be done, drape patient in a blanket, plastic, or sheet.

b. Supporting Emergency Plans

Radiation Emergency Plans have been prepared by the Department of Consumer and Regulatory Affairs of the Government of the District of Columbia. These plans provide for response, as appropriate, by the Fire Department (Fire and Ambulance Services), Police Department, Hospitals, and the Department of Consumer and Regulatory Affairs. The contact point for initiation of DC government assistance is the Office of Emergency Preparedness, manned on a 24 hour basis. All hospitals in the District of Columbia except the George Washington University Hospital and Sibley Memorial Hospital are prepared to receive and treat contaminated casualties. Because of its facilities and proximity to the University, the Washington Hospital Center, located at 110 Irving Street, NW (approximately one mile west of the campus), is the hospital of choice for contaminated casualties originating on campus.

c. Emergency Action

1. **DIAL** 202-**727-6161**, you will hear a recorded message. Immediately press 4 to reach the District Office of Emergency Preparedness which is manned 24 hours/day.

9.5 EMERGENCY PROCEDURES

2. **REPORT**

   Identify yourself and state "I have a radiation emergency."

   State the nature of the emergency, the number of contaminated casualties, their exact location, and the general nature of the injuries.

   Request Ambulance, Fire Equipment, Police, as appropriate.

   Tell the person answering the call to alert the emergency room at the WASHINGTON HOSPITAL CENTER.

3. **NOTIFY** the University's Radiation Safety Officer (ext **5206**). Contact Public Safety (ext **5111**), if assistance is needed in contacting the Radiation Safety Officer during non-business hours.

4. **STANDBY** to assist emergency response personnel as required. Post someone outside the building to direct emergency personnel to the scene.

5. **PREVENT** the spread of radioactive contamination by keeping bystanders away so that a radioactive spill is not spread unnecessarily. Unless prevented by fire, fumes, etc., keep the casualty in place to await arrival of emergency personnel.

6. **FIRST AID** measures, such as CPR or control of bleeding, should be used in the same manner as for a similar uncontaminated casualty. The quantities of radioactive material in use at the University are insufficient to pose a significant threat to the helper or attendant during the period from initial injury to treatment and decontamination at the hospital.

d. Minor Wounds Which May Be Contaminated

Minor cuts, abrasions, punctures, burns, etc., which may be contaminated, do not necessarily require activating the DC Government Radiation Emergency Plan. If a casualty can be transported to the Washington Hospital Center without risk of contaminating a District of Columbia ambulance, the following procedure may be preferable:

1. **CALL** Washington Hospital Center Emergency Room (202-**877-6701**). Tell them the nature of the casualty and the contaminant and that the casualty will be brought to the Emergency Room.

2. **CALL** the University's Radiation Safety Officer (ext **5206**). Contact Public Safety (ext **5111**), if assistance is needed in contacting the Radiation Safety Officer during non-business hours.

3. **REMOVE** contaminated clothing from the casualty. Replace it with a lab coat or other available garment. Cover contaminated shoes with plastic.

4. **WASH** contaminated skin with water and soap or mild detergent.

5. **WRAP** non-injured, contaminated skin areas with plastic, paper or cloth to minimize the likelihood of contamination of other clothing, skin and vehicle.

6. **INSTRUCT** the ambulance crew or vehicle driver to transport the casualty to the Washington Hospital Center Emergency Room, 110 Irving Street, NE, for wound decontamination and treatment.

e. Minor Wounds Not Requiring Medical Attention

If the concentration of radioactive material in the contaminating solution is known to be less than the maximum permissible concentration for unrestricted release (10 CFR 20, Appendix B, Table 2), the decision to seek medical attention can be made solely on the basis of the nature of the physical injury. If medical attention is not required, the following procedure will provide adequate decontamination:

1. Encourage bleeding to flush the wound, while irrigating with copious quantities of water.

2. Use the decontamination procedures of Section 9.5.5.

9.5.4.4 Explosion

Proper response to an explosion involving radioactive material consists of appropriate responses to the physical and radiological health hazards which accompany the explosion:

a. Airborne Contamination: See Section 9.5.4.1.

b. Contaminated Personnel: Without Injury: See Section 9.5.4.2.

c. Contaminated Personnel with Serious Injury: See Section 9.5.4.3.

d. Fire: See Section 9.5.4.5.

9.5.4.5 Fire

a. **ACTIVATE** the Building Fire Alarm

If the fire cannot be immediately extinguished (within a few seconds), activate the building fire alarm. Similarly, if an extinguished fire seriously compromised radioactive material storage areas or was likely to generate airborne radioactivity from an experiment in progress, activate the building fire alarm. If smoke or fumes interfere with breathing, the same procedure applies.

b. **CALL** Public Safety (Dial ext. **5111**)

State the nature of the emergency, the exact location, and request the fire department.

The Fire Department is summoned through the CUA dispatcher in Public Safety (ext. **5111**). Tell the dispatcher that radioactivity is involved. In turn, the dispatcher requests fire and related emergency response service. The dispatcher also sends officers from Public Safety so that personnel can be kept out of the building until the situation is brought under control and for assistance in directing Fire Department responders to the scene.

c. **PULL THE PLUG**

If electrical or electronic equipment is smoking or burning, the fault which caused the trouble could have by-passed switches and fuses. Most such fires go out when the plug is pulled. If fire threatens to spread, turn off all other electrical equipment (including window air conditioners) except hood blowers and evacuate the area.

d. **EVACUATE**

Attempt to verify that all students and personnel correctly responded to the building fire alarm and evacuated the area to a safe distance. Ensure that CUA personnel responding to the emergency are aware of any potential radiological hazard.

f. **STAND BY**

Take note of the events, people present, etc., while it is fresh in your mind. If there is any possibility that anyone is contaminated by radioactive material, request that they remain in the vicinity until they have been monitored for contamination.

9.5.4.6 External Radiation Exposure

There are no sources of ionizing radiation on the CUA campus of sufficient intensity that emergency response to external exposure could be required, therefore, no detailed plan for dealing with external radiation exposures is provided. However, the following guidelines are valid for any such incident:

a. Evacuate the victim from the radiation field to a non-radiation area.

b. Treat the victim for shock - keep the victim warm.

c. Use the Contaminated Casualty Plan, Section 9.5.4.3, to call for assistance.

9.5.4.7 Radioactive Spills

When radioactive material in liquid or powder form is spilled, the primary considerations are to (1) prevent the spread of the contamination, (2) prevent additional persons or objects from becoming contaminated, and (3) minimize the evaporation or suspension of the material into the room air.

a. Minor Spills

1. **NOTIFY** persons in the area

2. **PREVENT SPREAD**

- <u>Cover liquid spills</u> with absorbent paper.

- <u>Dampen dry spills</u> thoroughly, taking care not to spread the contamination. Use water unless chemical reaction with water could generate airborne contamination, in which case oil should be used. Cover dampened spill with absorbent paper.

- <u>Exclude</u> unnecessary personnel from the spill area.• <u>Mark off</u> spill area with chalk, marker pen or grease pencil; rope it off and post warning signs to create a personnel barrier.

- Hold potentially contaminated personnel in a nearby area until skin, clothing and footwear can be surveyed.
- Remove contaminated clothing before moving personnel to a clean area. Preserve the clothing for RSO evaluation.

3. **CLEAN UP**

Use disposable gloves (and remote handling tongs, if appropriate). Fold and insert absorbent paper into a plastic bag and discard in the radwaste container, together with other contaminated materials, such as disposable gloves. Follow RSO guidance with respect to further decontamination requirements.

NOTE: Except in cases of incapacitation, the primary responsibility for cleanup and decontamination rests with the person(s) responsible for the spill. The RSO's responsibility is to provide guidance and instruction so that it is done safely and adequately.

4. **SURVEY**

With a GM survey meter (other techniques may be required for tritium and some other isotopes), check the area around the spill, plus the hands, clothing and footwear of all potentially contaminated personnel.

5. **NOTIFY** the RSO (ext. **5206**) as soon as possible. Permit no one to resume work in the area until RSO approval is obtained.

b. Major Spills

A major spill is defined as a spill which entails a risk of airborne contamination in excess of the maximum permissible concentration in restricted areas (10 CFR 20, Appendix B, Table 1), or external radiation exposure rates in excess of 2 mrem/hr at 30 centimeters.

1. **CLEAR THE AREA**

Notify all persons not required for response to the spill to vacate the room.

2. **PREVENT SPREAD**

- Cover a liquid spill with absorbent paper, pads, or vermiculite, but do not attempt to clean it up.
- Dampen a dry spill with water (oil if chemical reaction with water could generate airborne contamination), then cover the spill as above.
- Confine the movement of potentially contaminated personnel until survey indicates they are uncontaminated.

WARNING: Do NOT attempt clean up unless properly trained or following RSO guidance.

3. **REDUCE EXPOSURE**

- If spill is on the skin, flush thoroughly with water and follow decontamination procedures in Section 9.5.5.

- If spill is on clothing, remove outer clothing at once. Place it in a plastic bag and preserve it for evaluation by the RSO.
- Shield the source, if penetrating radiation is involved AND if it can be done without further contamination or significantly increasing your radiation exposure.
- Switch OFF window air conditioners; leave hood blowers ON. If the room is served by an air conditioning system which also serves other rooms, evacuate all rooms served until they can be surveyed.

4. **CLOSE THE ROOM**

Leave the room and lock the doors to prevent entry.

5. **CALL FOR HELP**

Notify the RSO (ext. **5206**) as soon as possible. Permit no one to enter until RSO approval has been obtained.

9.5.5 Decontamination Procedures

9.5.5.1 General Principles of Decontamination

Successful decontamination calls for planned action. A spur-of-the moment action or attempt at decontamination can cause more harm than good. The person responsible for the spill in a contamination accident will usually take the first steps in bringing the situation under control. Those persons responsible for a spill shall, unless physically unable, be responsible for all decontamination of the area, under the supervision of the RSO. The first consideration shall be personnel safety; persons not involved in the emergency response shall leave the area. Subsequent considerations should involve the following procedures:

a. Prevent the spread of contamination by shutting off ventilation fans, applying absorbent material in the case of liquids (applying appropriate liquid and then absorbent material in the case of dry spills), and roping off, barricading or locking the area.

b. Immediately notify your supervisor and the RSO (ext. **5206**).

c. Allow no one who has been in the spill area to leave a nearby holding area until the person has been checked for contamination.

d. Make full use of monitoring instruments and available assistance. Each step of the decontamination should be monitored. One person free of contamination should remain to operate instruments and do other monitoring. (If the survey instrument becomes contaminated, further progress will be impaired.) Protective clothing, footwear, gloves, and respiratory equipment shall be used as needed.

9.5.5.2 General Procedures for Personnel Decontamination

Ordinarily, the same procedures used for personal cleanliness will suffice to remove radioactive contaminants from the skin, but the specific method will depend upon the form (grease, oil, etc.) of the contamination. Soap and water (sequestering agents and detergents) normally remove more than 99% of the contaminants. If it is necessary to remove the remainder, chemicals can be used on the outer layers of skin upon which the contamination has been deposited. Because of the risk of injury to the skin surface, these chemicals (citric acid, potassium permanganate, sodium bisulfite, etc.) should be applied with caution, preferably under medical supervision. Lanolin-based creams can be used to offset local irritation of skin surfaces after decontamination. Contaminants should be removed to the maximum feasible extent at the site of the incident.

Remove any clothing or personal protective equipment found to be contaminated before determining the level of skin contamination.

Decontaminate any areas of the body found to be significantly more contaminated than surrounding areas. This spot cleaning is necessary to reduce the spread of contamination to clean areas of the body which might otherwise occur during showering. Open wounds should be sealed or covered during this spot cleaning to prevent additional contamination from being washed into wounds.

If the contamination is general over large portions of the body surfaces, a very thorough shower is necessary. Special attention must be paid to such areas as the hair, hands and fingernails. After showering and subsequent monitoring, the residual contamination can be removed by spot cleaning.

Avoid the prolonged use of any one method of decontamination. Repeated ineffective decontamination methods may irritate the skin and thus hamper the success of more suitable procedures. No one chemical treatment is known to be specific for all of the elements with which one may become contaminated.

Avoid the use of organic solvents. Organic solvents may increase the probability of the radioactive materials penetrating the skin.

9.5.5.3 Hand Decontamination

Numerous excellent products are commercially available for general purpose decontamination. If one or more of these is available it can be used safely to remove hand contamination. In most instances nothing more will be required. A partial list of such products would include the trade names Lift Away, Micro, Rad-Con, and Radiac Wash. If none of these is available, or if their use is unsuccessful, one or more of the following techniques can be tried.

Wash the skin thoroughly with soap and water, paying special attention to areas between the fingers and around the fingernails. Repeat the procedure if monitoring indicates that there has been improvement but that there is contamination remaining on the skin.

Contact the RSO for guidance if successive washing does not remove the contamination.

9.5.5.4 Area Decontamination

When an area becomes contaminated, preparation for decontamination should be started promptly. This not only minimizes the likelihood of spread, but usually makes the job easier.

a. Cover clean areas in the vicinity with absorbent paper.

b. Control the flow of contaminated liquids: apply absorbers, establish barriers (absorbent dikes, etc.), seal cracks in floors, bench tops, etc.

c. Consider all run-off solutions, mops, rags and brushes used in the clean up to be contaminated until demonstrated otherwise.

d. Notify the RSO (ext. **5206**), who will assist in determining the extent of and the hazard associated with the contamination.

e. Decontamination Methods

NOTE: The following items require RSO Guidance or an RSO-approved procedure prior to start.

1. Detergent solutions; Radiac Wash, etc., may be used to decontaminate many smooth, non-porous surfaces.

2. Metals: Low-value metallic objects should be discarded to radwaste. Oily surface films may have to be removed before decontamination measures are effective. Various commercial degreasers and organic solvents may be considered, depending on the nature of the film to be removed. High normality acids, concentrated acids, or aqua regia may be used if needed and if the surfaces will withstand such treatment.

3. Concrete or brick: Solutions of hydrochloric acid (muriatic acid), used with commercial scrubbers may be employed. As concrete and brick are relatively porous, decontamination probably will not be completely successful.

4. Glassware: Appropriate solvents or detergents, or discard to radwaste.

5. Linoleum, asphalt tile, vinyl tile, etc.: If well-waxed before contamination, removal of wax with solvents or scouring powder and steel wool may adequately decontaminate. Or, the floor covering can be replaced. In some cases, a radioactive liquid will penetrate, via cracks and joints in the floor covering, to the main floor surface. It will then be necessary to remove the floor covering in the affected area and decontaminate the main floor surface.

6. Wood: Sand (with careful attention to dust control), plane, or discard to radwaste.

7. Painted surfaces: Paint removers.

f. Decontamination Standard

An area is considered free from radioactive contamination when a wipe test shows removable contamination to be less than 22 dpm/100 cm^2 for alpha emitting nuclides and 220 dpm/100 cm^2 for beta-gamma emitters (see Table 9.3.3.4). Higher limits may be tolerable in restricted areas and for release of certain equipment (See Section 9.3.12). Even so, the goal shall be to attain the lowest level that can be accomplished with reasonable effort.

9.6 GLOSSARY

9.6 GLOSSARY

Absorbed Dose -- The energy imparted by ionizing radiation per unit mass of irradiated material with a unit of rad or gray. (1 rad = 0.01 gray = 0.01 joule/kilogram)

Airborne Radioactive Material -- Radioactive material dispersed in the air in the form of dusts, fumes, particulates, mists, vapors, or gases.

Airborne Radioactivity Area -- A room, enclosure, or area in which airborne radioactive materials exist in concentrations in excess of the derived air concentrations (DACs) specified in 10 CFR 20, Appendix B.

ALARA -- Acronym for "as low as reasonably achievable".

Annual limit on intake (ALI) -- The derived limit for the amount of radioactive material that can be ingested or inhaled by an adult radiation worker in a year. ALIs for various nuclides are listed in 10 CFR 20, Appendix B, Table 1, Columns 1 and 2.

Approved Exhaust Ventilation -- A hood, glove box, or local exhaust facility which has been approved by the RSO for work with specific radioactive isotopes and activity concentrations. Approval is designated by printed labels attached to the ventilation unit by the RSO.

Authorization -- Authority granted by the RSC to a CUA investigator to use radioactive material of specified type(s) and quantities for stipulated purposes, as stated in Part D of Form RSO-2 "Application for Possession and Use of Radioactive Material."

Authorized User -- An individual granted an Authorization by the RSC.

Background Radiation -- Radiation from cosmic sources, naturally occurring radioactive materials, and global fallout as it exists in the environment. Background radiation does not include radiation from licensed or regulated source, byproduct, or special nuclear materials.

Bioassay -- The determination of the kind, quantity, concentration, and location of radioactive material in the human body by direct (in vivo) measurement, or by analysis (in vitro) of materials excreted or removed from the human body.

Byproduct Material -- Radioactive material yielded in or made radioactive by the process of producing or utilizing special nuclear material. A more detailed explanation of the term is provided in 10 CFR 20.

CFR -- Code of Federal Regulations

Consumable Radioactive Material -- Radioactive material withdrawn incrementally from a stock container for user-determined end use.]

Contaminated Casualty -- An individual who has (or is suspected to have): ingested or inhaled radioactive materials, had radioactive materials come into contact with the eyes or an open wound, or been injected with radioactive materials.

Contamination -- An unwanted presence of radioactive material on an object or person.

Controlled Area -- An area, outside of a restricted area but inside the site boundary, access to which can be limited by the licensee for any reason.

CUA -- The Catholic University of America

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Decontamination -- The removal of contamination to an acceptable level or activity concentration.

Declared Pregnant Woman -- A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

Derived Air Concentration (DAC) -- the concentration of a given radionuclide in air which, if breathed by the reference man for a working year of 2,000 hours under conditions of light work (inhaling 1.2 cubic meters of air per hour), would result in an intake of one ALI. DAC values for specific nuclides are listed in 10 CFR 20, Appendix B, Table 1, Column 3.

DC -- The District of Columbia.

DHHS -- The U.S. Department of Health and Human Services.

DOE -- The U.S. Department of Energy.

Dose Equivalent -- The product of the absorbed dose in tissue, quality factor of the radiation, and all other necessary modifying factors at the location of interest. The units of dose equivalent are the rem and the sievert.

dpm -- disintegrations per minute.

Embryo/fetus -- The developing human organism from conception until the time of birth.

Emergency (Radiation) -- Any incident resulting from the use of one or more sources of ionizing radiation that creates an internal or external hazard to personnel.

Exposure -- Being exposed to ionizing radiation or radioactive material.

External Dose -- That portion of the dose equivalent received from radiation sources outside the body.

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

Eye Dose Equivalent -- Applies to the external exposure of the lens of the eye and is taken at a tissue depth of 0.3 centimeter (300 mg/cm2).

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

Individual User -- Any person who works with sources of ionizing radiation under the supervision of an Authorized User.

Internal Dose -- That portion of the dose equivalent received from radioactive material taken into the body.

Licensed Material -- Source material, special nuclear material, or byproduct material received, possessed, used, transferred, or disposed of under a general or specific license issued by the NRC.

Limits (dose limits) -- The permissible upper bounds of radiation exposures or doses.

LSC -- Liquid scintillation counter.

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Major Spill -- A spill of radioactive material which entails a risk of airborne contamination in excess of the isotope specific maximum permissible concentration listed in 10 CFR 20, Appendix B Table 1, Columns 2 and/or 3; or entails risk of radiation exposure rates in excess of 50 mrem/hr (500 μSv) at 30 centimeters.

mrem -- millirem, 1/1,000th of a rem

mSv -- millisievert, 1/1,000th of a Sievert

NRC -- The U.S. Nuclear Regulatory Commission.

Occupational Dose -- The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation and to radioactive materials. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as member of the general public.

Potentially Exposed Personnel --Includes at a minimum, all persons authorized to work in the same room with radioactive material. If x-ray or gamma radiation generates dose rates in adjoining rooms that exceed the levels permissible in an unrestricted area, the personnel occupying those adjacent spaces would be included.

Principal Investigator -- The applicant named in an "Application for Possession and Use of Radioactive Material." The principal investigator becomes an Authorized User upon approval of the application by the RSC.

Principal User -- A person authorized by the RSC for unsupervised operation of a radiation producing machine.

Radiation -- Ionizing radiation in the form of alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in this manual, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infra-red, or ultraviolet light.

Radiation Area -- An area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 5 mrem (50 μSv) in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

Radiation Producing Equipment (RPE) or Machine (RPM) -- Any machine or equipment whose primary purpose is to produce ionizing radiation, or which produces ionizing radiation coincidental to its primary purpose.

Radiation Worker -- An individual, including Authorized User, employee, or student, who is permitted to work with one or more sources of ionizing radiation on the CUA campus in accordance with the administrative procedures set forth in this manual.

Radioactive Material -- Material which emits alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions.

Radioactive Waste (Radwaste) -- (1) Unsealed radioactive material whose retention is no longer desired by the responsible Authorized User, (2) Material/equipment presumed to be contaminated.

Rem -- Acronym for "Roentgen equivalent man", the special unit of dose equivalent (1 rem = 0.01 Sievert).

Restricted Area -- An area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.RMIC -- Radioactive Material Inventory Control.

RSC -- Radiation Safety Committee

9.6 GLOSSARY

RSL -- Radiation Safety Laboratory

RSO -- Radiation Safety Officer

Sievert -- The SI unit of any of the quantities expressed as a dose equivalent. (1 Sv = 100 rems).

Source of Ionizing Radiation -- Any isotope, regardless of chemical or physical form, which naturally or artificially radioactive, and whose quantity, total activity, or specific activity exceeds the limits established by law or regulation for exemption from controls established to protect the public health, or (2) Any radiation producing machine or equipment, as defined herein.

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

Special Nuclear Material -- (1) Plutonium, uranium-233, uranium enriched in the isotopes 233 or 235, or (2) Any material artificially enriched by any of the foregoing.

Stock Container -- A bulk or storage container from which material is incrementally withdrawn for user-determined end use.

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

Technical Member -- A member of the RSC, qualified by training and experience in the use of radioactive material or radiation producing equipment, appointed from a Department or Laboratory which uses sources of ionizing radiation.

Technician -- An individual authorized to operate a radiation producing machine under the supervision of a Principal User.

Total Effective Dose Equivalent (TEDE) -- The sum external and internal exposures.

Unrestricted Area -- An area, access to which is neither limited nor controlled by the licensee.

Unsealed Container -- A container of radioactive material which is open to the atmosphere or which has a closure intended for manual manipulation.

Whole Body -- For purpose of external exposure, the head, trunk, gonads, arms above the elbow and legs below the knee.

APPENDIX A: PUBLICATIONS AVAILABLE TO RADIATION WORKERS

Appendix A consists of three sections; Section A-1 lists those documents required by law (10 CFR 19) to be made available to radiation workers. Section A-2 contains the text of Title 10, Code of Federal Regulations, Part 19 (10 CFR 19), entitled "Notices, Instructions and Reports to Workers: Inspections and Investigations", and Section A-3 presents a reduced copy of NRC Form-3 entitled "Notice to Employees."

A-1 Documents Required By Law. The below-listed documents, required by 10 CFR 19.11 to be made available to radiation workers, are available for inspection in the CUA Radiation Safety Office.

a. 10 CFR 19 (also included in this appendix)
b. 10 CFR 20 "Standards for Protection Against Radiation"
c. NRC Form-3 "Notice to Employees"
d. CUA Byproduct Material License No. 08-02075-03
e. CUA Source Material License No. SUD-157
f. CUA Special Nuclear Material License No. SNM-164

Additional documents are available for review in the CUA Radiation Safety Office which may be useful in planning for the experimental use of ionizing radiation.

A-2 Text of 10 CFR Part 19.

NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS: INSPECTION AND INVESTIGATIONS

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19.18 Sequestration of witnesses and exclusion of counsel in interviews conducted under subpoena.
19.20 Employee protection.
19.30 Violations.
19.31 Application for exemptions.
19.32 Discrimination prohibited.
19.40 Criminal penalties.

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, sec. 1701, 106 Stat. 2951, 2952, 2953 (42 U.S.C. 2073, 2093, 2111, 2133, 2134, 2201, 2236, 2282, 2297f); sec. 201, 88 Stat. 1242, as amended (42 U.S.C. 5841); Pub. L. 95-601, sec. 10, 92 Stat. 2951 (42 U.S.C. 5851).

Source: 38 FR 22217, Aug. 17, 1973, unless otherwise noted.

APPENDIX A - PUBLICATIONS AVAILABLE TO RADIATION WORKERS

§ 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 these 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. The regulations in this part also establish the rights and responsibilities of the Commission and individuals during interviews compelled by subpoena as part of agency inspections or investigations pursuant to section 161c of the Atomic Energy Act of 1954, as amended, on any matter within the Commission's jurisdiction.

[55 FR 247, Jan. 4, 1990]

§ 19.2 Scope.

The regulations in this part apply to all persons who receive, possess, use, or transfer material licensed by the Nuclear Regulatory Commission pursuant to the regulations in parts 30 through 36, 39, 40, 60, 61, or part 72 of this chapter, including persons licensed to operate a production or utilization facility pursuant to part 50 of this chapter, persons licensed to possess power reactor spent fuel in an independent spent fuel storage installation (ISFSI) pursuant to part 72 of this chapter, and in accordance with 10 CFR 76.60 to persons required to obtain a certificate of compliance or an approved compliance plan under part 76 of this chapter. The regulations regarding interviews of individuals under subpoena apply to all investigations and inspections within the jurisdiction of the Nuclear Regulatory Commission other than those involving NRC employees or NRC contractors. The regulations in this part do not apply to subpoenas issued pursuant to 10 CFR 2.720.

[55 FR 247, Jan. 4, 1990]

§ 19.3 Definitions.

As used in this part:

Act means the Atomic Energy Act of 1954, (68 Stat. 919) including any amendments thereto.

Commission means the United States Nuclear Regulatory Commission.

Exclusion means the removal of counsel representing multiple interests from an interview whenever the NRC official conducting the interview has concrete evidence that the presence of the counsel would obstruct and impede the particular investigation or inspection.

License means a license issued under the regulations in parts 30 through 36, 39, 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. Licensee means the holder of such a license.

Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

Sequestration means the separation or isolation of witnesses and their attorneys from other witnesses and their attorneys during an interview conducted as part of an investigation, inspection, or other inquiry.

Worker means an individual engaged in activities licensed by the Commission and controlled by a licensee, but does not include the licensee.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 53 FR 31680, Aug. 19, 1988; 55 FR 247, Jan. 4, 1990; 56 FR 23470, May 21, 1991; 56 FR 65948, Dec. 19, 1991; 57 FR 61785, Dec. 29, 1992]

Effective Date Note: At 57 FR 61785, Dec. 29, 1992, § 19.3 was amended by adding the definition ``Exclusion'' effective March 1, 1993.

§ 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.

§ 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 Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in appendix D of part 20 of this chapter. Communications, reports, and applications may be delivered in person at the Commission's offices at 2120 L Street, NW., Washington, DC, or at 11555 Rockville Pike, Rockville, Maryland.

[53 FR 6138, Mar. 1, 1988, as amended at 53 FR 43420, Oct. 27, 1988]

§ 19.8 Information collection requirements: OMB approval.

(a) The Nuclear Regulatory Commission has submitted the information collection requirements contained in this part to the Office of Management and Budget (OMB) for approval as required by the Paperwork Reduction Act of 1980 (44 U.S.C. 3501 et seq.). OMB has approved the information collection requirements contained in this part under control number 3150-0044.

(b) The approved information collection requirements contained in this part appear in § 19.13.

[49 FR 19624, May 9, 1984]

§ 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.

(c) Each licensee and each applicant for a specific license shall prominently post NRC Form 3, (Revision dated June 1993), ``Notice to Employees."

Note: Copies of NRC Form 3 may be obtained by writing to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in appendix D to part 20 of this chapter or by contacting the NRC Information and Records Management Branch (telephone no. 301-492-8138).

(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.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 47 FR 30454, July 14, 1982; 52 FR

31610, Aug. 21, 1987]

§ 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:

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) Each licensee shall advise each worker annually of the worker's dose as shown in records maintained by the licensee pursuant to the provisions of § 20.2106 of 10 CFR part 20.

(c)(1) 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 and/or to radioactive material:

(i) As shown in records maintained by the licensee pursuant to § 20.2106 for each year the worker was required to be monitored under the provisions of § 20.1502; and

(ii) For each year the worker was required to be monitored under the monitoring requirements in effect prior to January 1, 1994.

(2) This report must 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. This report must cover the period of time that the worker's activities involved exposure to radiation from radioactive material licensed by the Commission and must include the dates and locations of licensed activities in which the worker participated during this period.

(d) When a licensee is required pursuant to §§ 20.2202, 20.2203, 20.2204, or 20.2206 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 or her exposure data included therein. This report must be transmitted at a time not later than the transmittal to the Commission.

(e) At the request of a worker who is terminating employment with the licensee that involved exposure to radiation or radioactive materials, during the current calendar quarter or the current year, each licensee shall provide at termination to each worker, or to the worker's designee, a written report regarding the radiation dose received by that worker from operations of the licensee during the current year or fraction thereof. If the most recent individual monitoring results are not available at that time, a written estimate of the dose must be provided together with a clear indication that this is an estimate.

§ 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.
(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 phrases 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.

§ 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 Administrator 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 Regional Office Administrator, 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 Regional Office Administrator 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 pursuant to this section need not be limited to matters referred to in the complaint.

[38 FR 22217, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 47 FR 30454, July 14, 1982; 52 FR 31610, Aug. 21, 1987]

§ 19.17 Inspections not warranted; informal review.

(a) If the Administrator 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 Operation, U.S. Nuclear Regulatory Commission, Washington, DC 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, modifying, or reverse the determination of the Administrator 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 Administrator 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, Aug. 17, 1973, as amended at 40 FR 8783, Mar. 3, 1975; 52 FR 31610, Aug. 21, 1987]

§ 19.18 Sequestration of witnesses and exclusion of counsel in interviews conducted under subpoena.

(a) All witnesses compelled by subpoena to submit to agency interviews shall be sequestered unless the official conducting the interviews permits otherwise.

(b) Any witness compelled by subpoena to appear at an interview during an agency inquiry may be accompanied, represented, and advised by counsel of his or her choice. However, when the agency official conducting the inquiry determines, after consultation with the Office of the General Counsel, that the agency has concrete evidence that the presence of an attorney representing multiple interests would obstruct and impede the investigation or inspection, the agency official may prohibit that counsel from being present during the interview.

(c) The interviewing official is to provide a witness whose counsel has been excluded under paragraph (b) of this section and the witness's counsel a written statement of the reasons supporting the decision to exclude. This statement, which must be provided no later than five working days after exclusion, must explain the basis for the counsel's exclusion. This statement must also advise the witness of the witness' right to appeal the exclusion decision and obtain an automatic stay of the effectiveness of the subpoena by filing a motion to quash the subpoena with the Commission within five days of receipt of this written statement.

(d) Within five days after receipt of the written notification required in paragraph (c) of this section, a witness whose counsel has been excluded may appeal the exclusion decision by filing a motion to quash the subpoena with the Commission. The filing of the motion to quash will stay the effectiveness of the subpoena pending the Commission's decision on the motion.

(e) If a witness' counsel is excluded under paragraph (b) of this section, the interview may, at the witness' request, either proceed without counsel or be delayed for a reasonable period of time to permit the retention of new counsel. The interview may also be rescheduled to a subsequent date established by the NRC, although the interview shall not be rescheduled by the NRC to a date that precedes the expiration of the time provided under § 19.18(d) for appeal of the exclusion of counsel, unless the witness consents to an earlier date.

[55 FR 247, Jan. 4, 1990, as amended at 56 FR 65948, Dec. 19, 1991; 57 FR 61785, Dec. 29, 1992]

Effective Date Note: At 57 FR 61785, Dec. 29, 1992, § 19.18 was amended by adding paragraphs (b) through (e) effective March 1, 1993.

§ 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 30454, July 14, 1982]

§ 19.30 Violations.

(a) The Commission may obtain an injunction or other court order to prevent a violation of the provisions of-
(1) The Atomic Energy Act of 1954, as amended;
(2) Title II of the Energy Reorganization Act of 1974, as amended; or
(3) A regulation or order issued pursuant to those Acts.
(b) The Commission may obtain a court order for the payment of a civil penalty imposed under section 234 of the Atomic Energy Act:
(1) For violations of-
(i) Sections 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Atomic Energy Act of 1954, as amended;
(ii) Section 206 of the Energy Reorganization Act;
(iii) Any rule, regulation, or order issued pursuant to the sections specified in paragraph (b)(1)(i) of this section;
(iv) Any term, condition, or limitation of any license issued under the sections specified in paragraph (b)(1)(i) of this section.
(2) For any violation for which a license may be revoked under section 186 of the Atomic Energy Act of 1954, as amended.

[57 FR 55071, Nov. 24, 1992]

§ 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 8783, Mar. 3, 1975]

§ 19.40 Criminal penalties.

(a) Section 223 of the Atomic Energy Act of 1954, as amended, provides for criminal sanctions for willful violation of, attempted violation of, or conspiracy to violate, any regulation issued under sections 161b, 161i, or 161o of the Act. For purposes of section 223, all the regulations in part 19 are issued under one or more of sections 161b, 161i, or 161o, except for the sections listed in paragraph (b) of this section.

(b) The regulations in part 19 that are not issued under sections 161b, 161i, or 161o for the purposes of section 223 are as follows: §§ 19.1, 19.2, 19.3, 19.4, 19.5, 19.8, 19.16, 19.17, 19.18, 19.30, 19.31, and 19.40.

[57 FR 55071, Nov. 24, 1992]

APPENDIX A - PUBLICATIONS AVAILABLE TO RADIATION WORKERS

A-3 NRC Form-3 “Notice to Employees”

APPENDIX B - RADIATION SAFETY OFFICE FORMS

APPENDIX B:
RADIATION SAFETY OFFICE FORMS
Form RSO-1: Radioactive Material Inventory Control

Form RSO-1
07-03

The Catholic University of America

RMIC#: ___________

RADIOACTIVE MATERIAL INVENTORY CONTROL

MATERIAL DESCRIPTION	
Isotope:	T1/2:
State: Solid Liquid Gas	Emissions: α β+ β− γ η
Chemical Form:	Volume or Mass:
Specific Activity:	Total Activity:

CUA ACQUISITION	
From:	Date:
Transfer Lic # (If Applicable):	

USER INFORMATION		
Received by:		Date:
Dept:	Auth User:	AU#:

WITHDRAWAL AND DISPOSITION RECORD

Date	By Whom (1)	Activity Removed	Running Inventory	Disposition or Withdrawal (2)

RETURN THIS FORM TO THE RSO WHEN INVENTORY IS REDUCED TO ZERO

Notes: (1) Enter “Decay” when correcting inventory record of short-lived isotopes for radioactive decay.
(2) If other than “radwaste” or to a supplementary RMIC, explain

User's Remarks:

APPENDIX B - RADIATION SAFETY OFFICE FORMS

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-2: Application for User Authorization
Page 1 of 3

The Catholic University of America

APPLICATION TO POSSESS AND USE RADIOACTIVE MATERIAL

Authorization No.: ______________

Expiration Date: ______________

INSTRUCTIONS: Complete this form in accordance with Appendix C of theRadiation safety Manual. Send the original and two copies to the Radiation safety Officer.

SECTION I

1. Identification of persons who will supervise the use of (a), who will use (b), and who may receive exposure (c) from radioactive material. (Name, title, department, building, room and phone number.)

1a. Principal Investigator:

1b. Users:

1c. Potentially Exposed Personnel:

2. Building and Room Numbers(s):

3. Description of Radioactive Material for Which Authorization is Sought

Element and Mass Number	Maximum activity		Chemical/Physical Form. If Sealed or Plated Source, State Name of Manufacturer, Model #, Number of Sources, and Maximum Activity per Source.
	To Be Possessed	In Use Per Experiment	

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-2: Application for User Authorization
Page 2 of 3

APPLICATION TO POSSESS AND USE RADIOACTIVE MATERIAL

4. Is any of the radioactive material to be used as a label for a potentially biohazardous material, toxic chemical, or carcinogenic/mutagenic material? YES___ NO___. (If YES, explain on a supplementary page.)

5. Describe the purpose for which the radioactive material will be used. If you need more space, check here ___ and continue on a supplemental page.

6. Principal procedures involved in the use of the material. Include procedures important to the consideration of contamination control, such as evaporation, transfer of powder, etc,

Nuclide	Activity (mCi)	Room Used	Exhaust Ventilation	Procedure Description

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-2: Application for User Authorization
Page 3 of 3

APPLICATION TO POSSESS AND USE RADIOACTIVE MATERIAL

7. RADIATION PROTECTION: Check special equipment which will be used to control and monitor external and internal radiation exposure. If you need additional space for explanation, check here ___ and continue on a supplemental page.

___ Glove Box	___ Tongs	___ Transportation Container
___ Fume Hood	___ Shoe covers	___ G. M. Survey Meter
___ Shielding	___ Mechanical Pipette	___ Scintillation Detection Survey Meter
___ Lab Coat	___ Shielded Storage Container	___ Ion Chamber Survey Meter
___ Trays	___ Radiation Signs & Labels	___ Other Survey Meter: ________________
___ Gloves	___ Bioassay	___ Pocket Dosimeter

___ Monitoring Badges: ___ Whole Body ___Wrist ___Finger

___ Other: ____

8. TRAINING AND EXPERIENCE: Complete and attach Form RSO-5 for each individual named in Sections 1a and 1b.

9. RADIATION DETECTION INSTRUMENTS

Type, Make, & Model #	Number of Units	Radiation Detected	Sensitivity Range (mr/h)	Window Thickness (cm)	Window Density (mg/cm2)	Use

CERTIFICATION: I certify that all information in this application, including any attached supplements, is true to the best of my knowledge and belief. I agree to abide by the letter and spirit of the Catholic University of America Radiation Safety Manual.

Principal Investigator: ______________________(Signature) Date: ________________

ADMINISTRATIVE ACKNOWLEDGEMENT:

Administrative Superior: ______________________(Signature) Date: ________________

Title: ____

APPENDIX B - RADIATION SAFETY OFFICE FORMS

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-3: Inventory of Sealed and Plated Radioactive Sources

Form RSO-3: Inventory of Sealed and Plated Radioactive Sources

Form RSO-3
6-79

THE CATHOLIC UNIVERSITY OF AMERICA

INVENTORY OF SEALED AND PLATED RADIOACTIVE SOURCES

Department ____________________ Authorized User ____________________

SOURCE DESCRIPTION	**ISOTOPE**	**ACTIVITY**		
		NOMINAL VALUE	**% UNCER-TAINTY**	**AS OF DATE**

I certify that this inventory is correct as of (Date) ______________________________

Signature ________________________________ Title ______________________________________

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-4: Qualifications of Principal Users of Radiation Producing Machines

Form RSO-4 **The Catholic University of America**

07-03

QUALIFICATIONS OF PRINCIPAL USERS OF RADIATION-PRODUCING MACHINES

Department: ____

Authorized User: ____

TYPE OF TRAINING	WHERE TRAINED	TRAINING DURATION	ON THE JOB	FORMAL COURSE
Principles and Practices of Radiation Protection			___Yes ___No	___Yes ___No
Basic Radiological Physics			___Yes ___No	___Yes ___No
Instrumentation, Mathematics, and Calculations Basic to the Use and Measurement of Radiation			___Yes ___No	___Yes ___No
Biological Effects of Radiation			___Yes ___No	___Yes ___No

TYPE OF DEGREE	NAME OF INSTITUTION

PROFESSIONAL CERTIFICATIONS:

EXPERIENCE WITH RADIATION PRODUCING MACHINES				
WHERE EXPERIENCE WAS GAINED	DURATION OF EXPERIENCE	TYPE OF EQUIPMENT OPERATED		

APPROVED BY RADIATION SAFETY COMMITTEE ON ______________________________ (DATE)

Form RSO-5 **The Catholic University of America**

07-03

QUALIFICATIONS OF INDIVIDUAL RADIONUCLIDE USERS

Name:			Date:	
Job Title:		Department:		
Type of Training	Where Trained	Training Duration	On-the Job	Formal Course
Principles and Practices of Radiation Protection			___ Yes ___ No	___ Yes ___ No
Basic Radiological Physics			___ Yes ___ No	___ Yes ___ No
Instrumentation, Mathematics, and Calculations Basic to the Use and Measurement of Radiation			___ Yes ___ No	___ Yes ___ No
Biological Effects of Radiation			___ Yes ___ No	___ Yes ___ No

Degree Type	Name of Institution

Professional Certifications:

Experience with Radiation (Actual Use of Isotopes)

Isotope	Maximum Amount	Where Experience Was Gained	Duration of Experience	Type of Use

APPENDIX B - RADIATION SAFETY OFFICE FORMS

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-6: Request for Issue of Personal Dosimetry

Form RSO-6
07-03

The Catholic University of America

REQUEST FOR DOSIMETRY SERVICE

TYPE OR PRINT LEGIBLY Date: ________________

Request that dosimetry service be provided for:

Full Name: ____
(Last) *(First)* *(Middle)*

Social Security Number: ___________________________ Date of Birth: ______________________

Department: ______________________________ Job Title: ______________________________

Nature of Assigned Work: ____

Supervisor: ____
(Signature)

____
(Print)

Read Carefully:

It is understood and agreed that while I am assigned to duties involving access to an area or facility, controlled or operated by CUA, wherein personnel may be exposed to ionizing radiation from equipment, radioactive sources, or radioactive material, I shall wear the radiation monitoring devices recommended or prescribed by the Radiation Safety Office whenever in such area or facility.

Also, it is understood and agreed that the safe operating procedures recommended or prescribed by the Radiation Safety Officer and the Laboratory to maintain exposure to radiation as low as is reasonably achievable shall be strictly complied with.

___ **I do** ___ **do not** have a previous occupational exposure history.
(Check one)

____
Signature of Dosimetry User

APPENDIX B
RADIATION SAFETY OFFICE FORMS
Form RSO-7: Request for Occupational Exposure Records

Form RSO-7
07-03

The Catholic University of America

REQUEST FOR OCCUPATIONAL RADIATION EXPOSURE RECORDS

I, ________________________________, request that data relating to occupational radiation
First Name *M.I.* *Last Name*

exposure I received while employed at or visiting facilities owned and/or operated by:

____
Company Name

____
Street Address

____
City *State* *Zip Code*

during the period ________________ to ______________be sent to the following address:
Start Date *End Date*

The Catholic University of America
Environmental Health & Safety
Radiation Safety Officer
Cardinal Station
Washington, DC 20064

Please include all information necessary to determine quarterly, annual, and total cumulative occupational exposure to ionizing radiation for the period requested.

My Social Security Number is _____-____-_____, and my date of birth is ____/____/____.

________________________________ ________________________
Signature Date

APPENDIX C - INSTRUCTIONS FOR COMPLETING THE APPLICATION FOR USER AUTHORIZATION

APPENDIX C

INSTRUCTIONS FOR COMPLETING THE APPLICATION FOR USER AUTHORIZATION (Form RSO-2)

The following instructions are keyed to the data entry numbers on the form:

1a. The principal investigator is the person who will be responsible for the safe storage and use of radioactive material by his/herself or others. Upon approval of the application by the RSC, the principal investigator becomes the "Authorized User" referred to throughout the Radiation Safety Manual.

1b. Users are persons who will work with the material with or without the direct supervision of the Authorized User. If the material is to be used by students in a directly supervised and regularly scheduled laboratory course, so indicate. Such students need not be named in the application.

1c. Potentially exposed personnel shall include at least all persons authorized to work in the same room with the material. In the case of penetrating radiation (x-rays and gamma rays) indicate contiguous rooms (including those above and below) or areas which could be affected by unshielded sources, if authority for sources in excess of one millicurie is requested.

2. Indicate the building and room number(s).

3a. Each isotope shall be identified by name or symbol of the chemical element and the mass number of the isotope (e.g., cesium-137 or Cs-137).

3b. The activities listed shall be the maximum quantity desired to be on hand at any one time, including that temporarily stored as radwaste, and the maximum amount to be authorized for use in any one experiment or procedure. The quantity shall be expressed in curies.

3c. The "form" is the chemical or physical state of the material as it will be received from the supplier. If more than one form of an isotope is desired, the application must list the quantities for each form in curies.

5. Describe the purpose of the use of radioactive material in sufficient detail that the nature of the experiment or procedure can be readily understood. The information provided in sections 5 & 6 shall be sufficient to identify those procedures which entail a risk of airborne suspension of volatile or powdered radioactive materials and the anticipated maximum temperature to which each different form of the radioactive material is intended to be subjected. Identify potential accident scenarios which could result in unplanned exposure to ionizing radiation or ingestion/inhalation of radioactive material by users or the general public.

6. Prepare this section so that a complete evaluation of the radiation hazards can be made; include all anticipated changes in the chemical or physical form of each isotope listed in section 3 of the form.

8. All pertinent training and experience with radioactivity or related fields must be submitted on the first application from an investigator. Subsequent applications may refer to prior applications and need only list relevant changes.

   a. List school or industrial or government facility where trained,

   b. State duration of training in weeks, semester hours, etc.,

   c. Indicate by check mark whether training was acquired on the job or in formal courses,

   d. If this is the first application submitted by the investigator, list all radioactive isotopes with which experienced (on subsequent applications list at least those isotopes for which authorization is requested), the maximum amount (in curies) used at one time, and briefly indicate the nature of such use. If a supplemental page is required, so indicate and append.

9. Describe the instruments to be used for radiation exposure control and for experimentation. In the case of standard commercial instruments, provide a descriptive name for the instrument and list the name of the manufacturer, model number, and year of manufacture (or the approximate age of the instrument).

10. The application must be signed by the applicant and the immediate administrative supervisor (Department Chair, Laboratory Director, or Dean). The signature of the superior is necessary to signify administrative, if not technical, knowledge of the authorization sought.

Radiation-Producing Equipment

Proposals and requests concerning radiation-producing equipment and machines (as defined in Section 9.3.13) shall include a detailed description of each radiation-producing machine or piece of equipment. At a minimum, the information provided to the RSO by the proposed user shall include:

a. The manufacturer's name, address, telephone number and local representative, if any;

b. The name, model number and serial number of the unit;

c. The nature and intensity of the radiation emitted;

d. Whether the radiation field is confined within the equipment or extends outside the equipment during normal operation or when the equipment is accessed for maintenance;

e. In the case of equipment intended to produce an ionizing radiation field external to the equipment, the field shall be sufficiently characterized to permit assessment of the radiological health implications of its use;

f. Identification of safety devices incorporated to protect the operator and others from the harmful effects of such radiation.

APPENDIX D
DISPOSAL OF RADIOACTIVE WASTE & SURPLUS RADIOACTIVE SOURCES

D-1 Definition

Radioactive waste (radwaste) is defined to mean:

a. Unsealed radioactive material, regardless of chemical or physical form, whose retention is no longer desired by the responsible Authorized User,

b. Material or equipment that is contaminated , or is presumed to be contaminated because of its use in association with radioactive material (e.g., disposable gloves and other protective clothing, glassware, tray and bench covers, tools, etc.),

c. Sealed sources of radioactive material which have been determined by the RSO to be leaking beyond allowable limits or reduced below useful activity through radioactive decay.

D-2 Introduction

This Appendix provides detailed instructions for the handling of all radwaste generated on the CUA campus, from its initial generation in the laboratories of Authorized Users until it is lawfully removed from the campus. Radwaste shall be disposed of only in accordance with the provisions of this Appendix. Specifically radwaste shall **NOT** be:

a. Incinerated on the CUA campus,

b. Buried on the CUA campus,

c. Deposited in ordinary trash containers,

d. Transported off campus except by duly licensed persons, or

e. Discharged to the sewer via laboratory sinks.

D-3 Disposal to the Sewer

The RSO is authorized to release radioactive waste to the sewer in accordance with applicable regulations. Users shall not release radioactive material to the sewer except that incidental to the routine cleaning of laboratory equipment.

The RSO shall maintain a log of all radioactive waste released to the sewer. The record shall include the release date, the isotope, and the activity of the release.

D-4 Release to Ventilation Exhaust Systems

D-4.1 Release Control

All operations in which significant atmospheric radioactive contamination could be produced shall be performed using local air filtration, a glove box, a fume hood, or combination thereof as set forth in the User Authorization.

D-4.2 Releases to Outdoor Air

In the case of a duct exhausting directly to the atmosphere (e.g., fume hood or glove box exhaust), the RSO shall be notified immediately if there is a release of airborne radioactive material in concentrations which, if averaged over a period of 24 hours would exceed the limits specified for the material in 10 CFR 20, Appendix B, Table II, Column 1.

D-4.3 Permissible Averaging Time

Determinations of the average concentration of radioactive material may be made with respect to the point where the material leaves the exhaust duct. Concentrations may not be averaged over a period longer than 24 hours without prior authorization of the RSC.

D-5 Specific Disposal Instructions for Radwaste

All radwaste shall be segregated into special collection containers in accordance with the rules contained in this Section.

D-5.1 Definitions

For waste management purposes, radwaste shall be categorized by class and isotope. Five classes will used: Animal, Aqueous, Dry, LSC, and Organic

a. Animal: Animal carcasses contaminated with radioactive material (internally and/or externally).

b. Aqueous: Liquid radwaste whose primary solvent is water. It may contain dissolved or suspended organic matter.

c. Dry: Radwaste, except used liquid scintillation vials, which contains no free liquid, either because the material is "dry" in the conventional sense or because an approved material has been added to absorb small quantities of free liquid which may be present.

d. LSC: Liquid scintillation cocktail which contains radioactive material.

e. Organic: Radwaste whose solvent(s) consist solely of organic liquid(s). It may contain dissolved or suspended inorganic matter. It shall not include scintillation cocktail, whether radioactive or not.

D-5.2 Segregation

The Authorized User is responsible for segregation of radwaste by class and within class; by isotope. LSC waste shall also be segregated by product name and labeled as “water soluble or “not water soluble.”

D-5.3 Radwaste Containers in Use

a. Containers employed for temporary accumulation of radwaste shall be:

- Distinctively different from trash containers used for non-radioactive trash;

- Conspicuously marked on opposite sides with the radiation symbol (10 CFR 20.203), together with the words "Caution - Radioactive Material";

- Conspicuously labeled to indicate the class of radwaste and the isotope contained;

D-5.4 Exposure Limitation

a. Controlled Areas

The total amount of radwaste placed in any container shall be controlled so that the radiation dose rate at one foot from the container is less than 2 mrem/hr and the dose rate at contact with any surface of the container is less than 5 mrem/hr.

b. Restricted Areas

The total amount of radwaste placed in any container shall be controlled so that the radiation dose rate at one foot from the container is less than 5 mrem/hr and the dose rate at contact with any surface of the container is less than 10 mrem/hr.

D-5.5 Precautions Against Chemical Reaction

Material shall not be put into a radwaste collection container if there is any possibility of a chemical reaction during storage which might cause fire or explosion, or cause the release of chemically toxic or radioactive gases. Solutions shall be adjusted to pH 6-8 prior to disposal into a liquid container.

D-5.6 Animal Carcasses

Small animal carcasses containing administered radionuclides shall be placed in sealed plastic bags, tagged with the date of disposal, animal type, the isotope and the total activity in millicuries. The carcasses shall then be stored in an appropriately labeled freezer until the isotope decays to background levels or arrangements have been made with the RSO for disposal by a licensed commercial firm.

D-5.7 Labeling

Upon completion of accumulation, a radioactive material label shall be affixed to each container of radwaste. The label shall bear the following minimum information:

- the date the package or container was prepared,
- the name of the Authorized User,
- the waste class, and
- the isotopes contained and their total activity (in millicuries).

Labels on containers of LSC waste shall also include the commercial or product name of the cocktail and state whether or not the cocktail is water soluble. LSC waste containing only H-3 or C-14 activity shall also state on the label whether the activity concentration is "LOW" (< 50 nCi/gm) or "HIGH" (> 50 nCi/gm).

D-5.8 Removal

Radwaste properly packaged and labeled will be picked up from individual laboratories by the RSO and transported to the CUA radwaste storage and handling facility for interim management and ultimate shipment to a licensed low level waste site. Requests for pick up of radwaste can be placed with the RSO by calling the Radiation Safety Office (ext. **5206**).

D-5.9 Storage

The RSO is authorized to store radwaste in the CUA Radioactive Materials Storage Facility (RMSF), for the purpose of accumulating shipments of economical size for transport to a licensed low level waste site. In the event that access to a low level waste site is denied, the RSO is authorized to store radwaste in the RMSF until site access is restored.

D-5.10 Storage for Decay

In accordance with the provisions contained in the byproduct license, the RSO is authorized to store-for-decay in the CUA Radioactive Materials Storage Facility (RMSF), radwastes that contain only isotopes of short half-life ($T_{½}$ < 120 days).

D-6 Disposal of Surplus Radioactive Sources

D-6.1 Sources Surplus to the Needs of an Authorized User

A radioactive source, other than consumable radioactive material, which is surplus to the needs of an Authorized User, may be transferred to another Authorized User in accordance with Section 9.2.9 of this manual, or transferred to the RSO.

D-6.2 Sources Surplus to the Needs of the University

The RSO may take the following action with respect to a radioactive source, other than consumable radioactive material, which is transferred as surplus by an Authorized User:

a. Transfer the source to another Authorized User who has a need and an Authorization for it,

b. Retain the source for the University,

c. Dispose of the source in accordance with applicable regulations and/or loan agreements (in cases where the source is not owned by CUA).

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Hydrogen-3	1,000
Beryllium-7	1,000
Beryllium-10	1
Carbon-11	1,000
Carbon-14	1,000
Fluorine-18	1,000
Sodium-22	10
Sodium-24	100
Magnesium-28	100
Aluminum-26	10
Silicon-31	1,000
Silicon-32	1
Phosphorus-32	10
Phosphorus-33	100
Sulfur-35	100
Chlorine-36	10
Chlorine-38	1,000
Chlorine-39	1,000
Argon-39	1,000
Argon-41	1,000
Potassium-40	100
Potassium-42	1,000
Potassium-43	1,000
Potassium-44	1,000
Potassium-45	1,000
Calcium-41	100
Calcium-45	100
Calcium-47	100
Scandium-43	1,000
Scandium-44m	100
Scandium-44	100
Scandium-46	10
Scandium-47	100
Scandium-48	100
Scandium-49	1,000
Titanium-44	1
Titanium-45	1,000
Vanadium-47	1,000
Vanadium-48	100
Vanadium-49	1,000
Chromium-48	1,000
Chromium-49	1,000
Chromium-51	1,000
Manganese-51	1,000
Manganese-52m	1,000
Manganese-52	100
Manganese-53	1,000
Manganese-54	100
Manganese-56	1,000
Iron-52	100
Iron-55	100
Iron-59	10
Iron-60	1
Cobalt-55	100
Cobalt-56	10
Cobalt-57	100
Cobalt-58m	1,000
Cobalt-58	100
Cobalt-60m	1,000
Cobalt-60	1
Cobalt-61	1,000
Cobalt-62m	1,000
Nickel-56	100
Nickel-57	100

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Nickel-59	100
Nickel-63	100
Nickel-65	1,000
Nickel-66	10
Copper-60	1,000
Copper-61	1,000
Copper-64	1,000
Copper-67	1,000
Zinc-62	100
Zinc-63	1,000
Zinc-65	10
Zinc-69m	100
Zinc-69	1,000
Zinc-71m	1,000
Zinc-72	100
Gallium-65	1,000
Gallium-66	100
Gallium-67	1,000
Gallium-68	1,000
Gallium-70	1,000
Gallium-72	100
Gallium-73	1,000
Germanium-66	1,000
Germanium-67	1,000
Germanium-68	10
Germanium-69	1,000
Germanium-71	1,000
Germanium-75	1,000
Germanium-77	1,000
Germanium-78	1,000
Arsenic-69	1,000
Arsenic-70	1,000
Arsenic-71	100
Arsenic-72	100
Arsenic-73	100
Arsenic-74	100
Arsenic-76	100
Arsenic-77	100
Arsenic-78	1,000
Selenium-70	1,000
Selenium-73m	1,000
Selenium-73	100
Selenium-75	100
Selenium-79	100
Selenium-81m	1,000
Selenium-81	1,000
Selenium-83	1,000
Bromine-74m	1,000
Bromine-74	1,000
Bromine-75	1,000

Bromine-76	100
Bromine-77	1,000
Bromine-80m	1,000
Bromine-80	1,000
Bromine-82	100
Bromine-83	1,000
Bromine-84	1,000

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Krypton-85	1,000
Krypton-87	1,000
Krypton-88	1,000
Rubidium-79	1,000
Rubidium-81m	1,000
Rubidium-81	1,000
Rubidium-82m	1,000
Rubidium-83	100
Rubidium-84	100
Rubidium-86	100
Rubidium-87	100
Rubidium-88	1,000
Rubidium-89	1,000
Strontium-80	100
Strontium-81	1,000
Strontium-83	100
Strontium-85m	1,000
Strontium-85	100
Strontium-87m	1,000
Strontium-89	10
Strontium-90	0.1
Strontium-91	100
Strontium-92	100
Yttrium-86m	1,000
Yttrium-86	100
Yttrium-87	100
Yttrium-88	10
Yttrium-90m	1,000
Yttrium-90	10
Yttrium-91m	1,000
Yttrium-91	10
Yttrium-92	100
Yttrium-93	100
Yttrium-94	1,000
Yttrium-95	1,000
Zirconium-86	100
Zirconium-88	10
Zirconium-89	100
Zirconium-93	1
Zirconium-95	10
Zirconium-97	100
Niobium-88	1,000
Niobium-89m (66 min)	1,000
Niobium-89 (122 min)	1,000
Niobium-90	100
Niobium-93m	10
Niobium-94	1
Niobium-95m	100
Niobium-95	100
Niobium-96	100
Krypton-74	1,000
Krypton-76	1,000
Krypton-77	1,000
Krypton-79	1,000
Krypton-81	1,000
Krypton-83m	1,000
Krypton-85m	1,000
Niobium-97	1,000
Niobium-98	1,000
Molybdenum-90	100
Molybdenum-93m	100
Molybdenum-93	10
Molybdenum-99	100
Molybdenum-101	1,000
Technetium-93m	1,000
Technetium-93	1,000
Technetium-94m	1,000
Technetium-94	1,000
Technetium-96m	1,000
Technetium-96	100
Technetium-97m	100

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Technetium-97	1,000
Technetium-98	10
Technetium-99m	1,000
Technetium-99	100
Technetium-101	1,000
Technetium-104	1,000
Ruthenium-94	1,000
Ruthenium-97	1,000
Ruthenium-103	100
Ruthenium-105	1,000
Ruthenium-106	1
Rhodium-99m	1,000
Rhodium-99	100
Rhodium-100	100
Rhodium-101m	1,000
Rhodium-101	10
Rhodium-102m	10
Rhodium-102	10
Rhodium-103m	1,000
Rhodium-105	100
Rhodium-106m	1,000
Rhodium-107	1,000
Palladium-100	100
Palladium-101	1,000
Palladium-103	100
Palladium-107	10
Palladium-109	100
Silver-102	1,000
Silver-103	1,000
Silver-104m	1,000
Silver-104	1,000
Silver-105	100
Silver-106m	100
Silver-106	1,000
Silver-108m	1
Silver-110m	10

Silver-111	100
Silver-112	100
Silver-115	1,000
Cadmium-104	1,000
Cadmium-107	1,000
Cadmium-109	1
Cadmium-113m	0.1
Cadmium-113	100
Cadmium-115m	10
Cadmium-115	100
Cadmium-117m	1,000
Cadmium-117	1,000
Indium-109	1,000
Indium-110 (69.1min.)	1,000

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Tin-113	100
Tin-117m	100
Tin-119m	100
Tin-121m	100
Tin-121	1,000
Tin-123m	1,000
Tin-123	10
Tin-125	10
Tin-126	10
Tin-127	1,000
Tin-128	1,000
Antimony-115	1,000
Antimony-116m	1,000
Antimony-116	1,000
Antimony-117	1,000
Antimony-118m	1,000
Antimony-119	1,000
Antimony-120 (16min.)	1,000
Antimony-120 (5.76d)	100
Antimony-122	100
Antimony-124m	1,000
Antimony-124	10
Antimony-125	100
Antimony-126m	1,000
Antimony-126	100
Antimony-127	100
Antimony-128 (10.4min.) ..	1,000
Antimony-128 (9.01h)	100
Antimony-129	100
Antimony-130	1,000
Antimony-131	1,000
Tellurium-116	1,000
Tellurium-121m	10
Tellurium-121	100
Tellurium-123m	10
Tellurium-123	100
Tellurium-125m	10
Tellurium-127m	10
Tellurium-127	1,000
Tellurium-129m	10
Tellurium-129	1,000
Tellurium-131m	10
Tellurium-131	100

Indium-110 (4.9h).........	1,000
Indium-111	100
Indium-112	1,000
Indium-113m	1,000
Indium-114m	10
Indium-115m	1,000
Indium-115	100
Indium-116m	1,000
Indium-117m	1,000
Indium-117	1,000
Indium-119m	1,000
Tin-110	100
Tin-111	1,000

Tellurium-132	10
Tellurium-133m	100
Tellurium-133	1,000
Tellurium-134	1,000
Iodine-120m	1,000
Iodine-120	100
Iodine-121	1,000
Iodine-123	100
Iodine-124	10
Iodine-125	1
Iodine-126	1
Iodine-128	1,000
Iodine-129	1
Iodine-130	10
Iodine-131	1
Iodine-132m	100
Iodine-132	100
Iodine-133	10
Iodine-134	1,000
Iodine-135	100
Xenon-120	1,000

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Xenon-121	1,000
Xenon-122	1,000
Xenon-123	1,000
Xenon-125	1,000
Xenon-127	1,000
Xenon-129m	1,000
Xenon-131m	1,000
Xenon-133m	1,000
Xenon-133	1,000
Xenon-135m	1,000
Xenon-135	1,000
Xenon-138	1,000
Cesium-125	1,000
Cesium-127	1,000
Cesium-129	1,000
Cesium-130	1,000
Cesium-131	1,000
Cesium-132	100
Cesium-134m	1,000
Cesium-134	10
Cesium-135m	1,000
Cesium-135	100

Cesium-136	10
Cesium-137	10
Cesium-138	1,000
Barium-126	1,000
Barium-128	100
Barium-131m	1,000
Barium-131	100
Barium-133m	100
Barium-133	100
Barium-135m	100
Barium-139	1,000
Barium-140	100
Barium-141	1,000
Barium-142	1,000
Lanthanum-131	1,000
Lanthanum-132	100
Lanthanum-135	1,000
Lanthanum-137	10
Lanthanum-138	100
Lanthanum-140	100
Lanthanum-141	100

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (μCi)
Neodymium-138	100
Neodymium-139m	1,000
Neodymium-139	1,000
Neodymium-141	1,000
Neodymium-147	100
Neodymium-149	1,000
Neodymium-151	1,000
Promethium-141	1,000
Promethium-143	100
Promethium-144	10
Promethium-145	10
Promethium-146	1
Promethium-147	10
Promethium-148m	10
Promethium-148	10
Promethium-149	100
Promethium-150	1,000
Promethium-151	100
Samarium-141m	1,000
Samarium-141	1,000
Samarium-142	1,000
Samarium-145	100
Samarium-146	1
Samarium-147	100
Samarium-151	10
Samarium-153	100
Samarium-155	1,000
Samarium-156	1,000
Europium-145	100
Europium-146	100
Europium-147	100
Europium-148	10
Europium-149	100
Europium-150 (12.62h)	100
Europium-150 (34.2y)	1
Europium-152m	100

Lanthanum-142	1,000
Lanthanum-143	1,000
Cerium-134	100
Cerium-135	100
Cerium-137m	100
Cerium-137	1,000
Cerium-139	100
Cerium-141	100
Cerium-143	100
Cerium-144	1
Praseodymium-136	1,000
Praseodymium-137	1,000
Praseodymium-138m	1,000
Praseodymium-139	1,000
Praseodymium-142m	1,000
Praseodymium-142	100
Praseodymium-143	100
Praseodymium-144	1,000
Praseodymium-145	100
Praseodymium-147	1,000
Neodymium-136	1,000
Europium-152	1
Europium-154	1
Europium-155	10
Europium-156	100
Europium-157	100
Europium-158	1,000
Gadolinium-145	1,000
Gadolinium-146	10
Gadolinium-147	100
Gadolinium-148	0.001
Gadolinium-149	100
Gadolinium-151	10
Gadolinium-152	100
Gadolinium-153	10
Gadolinium-159	100
Terbium-147	1,000
Terbium-149	100
Terbium-150	1,000
Terbium-151	100
Terbium-153	1,000
Terbium-154	100
Terbium-155	1,000
Terbium-156m (5.0h)	1,000
Terbium-156m (24.4h)	1,000
Terbium-156	100
Terbium-157	10
Terbium-158	1
Terbium-160	10

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (μCi)
Terbium-161	100
Dysprosium-155	1,000
Dysprosium-157	1,000
Dysprosium-159	100
Dysprosium-165	1,000
Dysprosium-166	100
Holmium-155	1,000
Holmium-157	1,000

Holmium-159	1,000
Holmium-161	1,000
Holmium-162m	1,000
Holmium-162	1,000
Holmium-164m	1,000
Holmium-164	1,000
Holmium-166m	1
Holmium-166	100
Holmium-167	1,000
Erbium-161	1,000
Erbium-165	1,000
Erbium-169	100
Erbium-171	100
Erbium-172	100
Thulium-162	1,000
Thulium-166	100
Thulium-167	100
Thulium-170	10
Thulium-171	10
Thulium-172	100
Thulium-173	100
Thulium-175	1,000
Ytterbium-162	1,000
Ytterbium-166	100
Ytterbium-167	1,000
Ytterbium-169	100
Ytterbium-175	100
Ytterbium-177	1,000

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Tantalum-172	1,000
Tantalum-173	1,000
Tantalum-174	1,000
Tantalum-175	1,000
Tantalum-176	100
Tantalum-177	1,000
Tantalum-178	1,000
Tantalum-179	100
Tantalum-180m	1,000
Tantalum-180	100
Tantalum-182m	1,000
Tantalum-182	10
Tantalum-183	100
Tantalum-184	100
Tantalum-185	1,000
Tantalum-186	1,000
Tungsten-176	1,000
Tungsten-177	1,000
Tungsten-178	1,000
Tungsten-179	1,000
Tungsten-181	1,000
Tungsten-185	100
Tungsten-187	100
Tungsten-188	10
Rhenium-177	1,000
Rhenium-178	1,000
Rhenium-181	1,000
Rhenium-182 (12.7h)	1,000
Rhenium-182 (64.0h)	100
Ytterbium-178	1,000
Lutetium-169	100
Lutetium-170	100
Lutetium-171	100
Lutetium-172	100
Lutetium-173	10
Lutetium-174m	10
Lutetium-174	10
Lutetium-176m	1,000
Lutetium-176	100
Lutetium-177m	10
Lutetium-177	100
Lutetium-178m	1,000
Lutetium-178	1,000
Lutetium-179	1,000
Hafnium-170	100
Hafnium-172	1
Hafnium-173	1,000
Hafnium-175	100
Hafnium-177m	1,000
Hafnium-178m	0.1
Hafnium-179m	10
Hafnium-180m	1,000
Hafnium-181	10
Hafnium-182m	1,000
Hafnium-182	0.1
Hafnium-183	1,000
Hafnium-184	100
Rhenium-184m	10
Rhenium-184	100
Rhenium-186m	10
Rhenium-186	100
Rhenium-187	1,000
Rhenium-188m	1,000
Rhenium-188	100
Rhenium-189	100
Osmium-180	1,000
Osmium-181	1,000
Osmium-182	100
Osmium-185	100
Osmium-189m	1,000
Osmium-191m	1,000
Osmium-191	100
Osmium-193	100
Osmium-194	1
Iridium-182	1,000
Iridium-184	1,000
Iridium-185	1,000
Iridium-186	100
Iridium-187	1,000
Iridium-188	100
Iridium-189	100
Iridium-190m	1,000
Iridium-190	100
Iridium-192 (73.8d)	1
Iridium-192m (1.4min.)	10
Iridium-194m	10
Iridium-194	100
Iridium-195m	1,000
Iridium-195	1,000
Platinum-186	1,000
Platinum-188	100
Platinum-189	1,000

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

APPENDIX E - REPRODUCTION OF 10 CFR 20; APPENDIX C

Radionuclide	Quantity (µCi)
Platinum-191	100
Platinum-193m	100
Platinum-193	1,000
Platinum-195m	100
Platinum-197m	1,000
Platinum-197	100
Platinum-199	1,000
Platinum-200	100
Gold-193	1,000
Gold-194	100
Gold-195	10
Gold-198m	100
Gold-198	100
Gold-199	100
Gold-200m	100
Gold-200	1,000
Gold-201	1,000
Mercury-193m	100
Mercury-193	1,000
Mercury-194	1
Mercury-195m	100
Mercury-195	1,000
Mercury-197m	100
Mercury-197	1,000
Mercury-199m	1,000
Mercury-203	100
Thallium-194m	1,000
Thallium-194	1,000
Thallium-195	1,000

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (µCi)
Polonium-205	1,000
Polonium-207	1,000
Polonium-210	0.1
Astatine-207	100
Astatine-211	10
Radon-220	1
Radon-222	1
Francium-222	100
Francium-223	100
Radium-223	0.1
Radium-224	0.1
Radium-225	0.1
Radium-226	0.1
Radium-227	1,000
Radium-228	0.1
Actinium-224	1
Actinium-225	0.01
Actinium-226	0.1
Actinium-227	0.001
Actinium-228	1
Thorium-226	10
Thorium-227	0.01

Thallium-197	1,000
Thallium-198m	1,000
Thallium-198	1,000
Thallium-199	1,000
Thallium-200	1,000
Thallium-201	1,000
Thallium-202	100
Thallium-204	100
Lead-195m	1,000
Lead-198	1,000
Lead-199	1,000
Lead-200	100
Lead-201	1,000
Lead-202m	1,000
Lead-202	10
Lead-203	1,000
Lead-205	100
Lead-209	1,000
Lead-210	0.01
Lead-211	100
Lead-212	1
Lead-214	100
Bismuth-200	1,000
Bismuth-201	1,000
Bismuth-202	1,000
Bismuth-203	100
Bismuth-205	100
Bismuth-206	100
Bismuth-207	10
Bismuth-210m	0.1
Bismuth-210	1
Bismuth-212	10
Bismuth-213	10
Bismuth-214	100
Polonium-203	1,000
Thorium-228	0.001
Thorium-229	0.001
Thorium-230	0.001
Thorium-231	100
Thorium-232	100
Thorium-234	10
Thorium-natural	100
Protactinium-227	10
Protactinium-228	1
Protactinium-230	0.1
Protactinium-231	0.001
Protactinium-232	1
Protactinium-233	100
Protactinium-234	100
Uranium-230	0.01
Uranium-231	100
Uranium-232	0.001
Uranium-233	0.001
Uranium-234	0.001
Uranium-235	0.001
Uranium-236	0.001
Uranium-237	100
Uranium-238	100
Uranium-239	1,000
Uranium-240	100
Uranium-natural	100
Neptunium-232	100
Neptunium-233	1,000
Neptunium-234	100
Neptunium-235	100
Neptunium-236 (1.15x10↑5y)	0.001

APPENDIX E - REPRODUCTION OF 10 CFR 20; APPENDIX C

Neptunium-236 (22.5h)	1
Neptunium-237	1.001
Neptunium-238	10
Neptunium-239	100
Neptunium-240	1,000
Plutonium-234	10
Plutonium-235	1,000
Plutonium-236	0.001
Plutonium-237	100
Plutonium-238	0.001
Plutonium-239	0.001

Appendix C to 10 CFR Part 20
Quantities{1} of Licensed Material
Requiring Labeling

Radionuclide	Quantity (μCi)
Plutonium-240	0.001
Plutonium-241	0.01
Plutonium-242	0.001
Plutonium-243	1,000
Plutonium-244	0.001
Plutonium-245	100
Americium-237	1,000
Americium-238	100
Americium-239	1,000
Americium-240	100
Americium-241	0.001
Americium-242m	0.001
Americium-242	10
Americium-243	0.001
Americium-244m	100
Americium-244	10
Americium-245	1,000
Americium-246m	1,000
Americium-246	1,000
Curium-238	100
Any radionuclide other than alpha emitting nuclides not listed above, or mixtures of beta emitters of unknown composition	0.01
Curium-240	0.1
Curium-241	1
Curium-242	0.01
Curium-243	0.001
Curium-244	0.001
Curium-245	0.001
Curium-246	0.001
Curium-247	0.001
Curium-248	0.001
Curium-249	1,000
Berkelium-245	100
Berkelium-246	100
Berkelium-247	0.001
Berkelium-249	0.1
Berkelium-250	10
Californium-244	100
Californium-246	1
Californium-248	0.01
Californium-249	0.001
Californium-250	0.001
Californium-251	0.001
Californium-252	0.001
Californium-253	0.1
Californium-254	0.001
Einsteinium-250	100
Einsteinium-251	100
Einsteinium-253	0.1
Einsteinium-254m	1
Einsteinium-254	0.01
Fermium-252	1
Fermium-253	1
Fermium-254	10
Fermium-255	1
Fermium-257	0.01
Mendelevium-257	10
Mendelevium-258	0.01
Any alpha emitter not shown above or alpha mixtures of unknown composition.	0.001

{1} The quantities listed above were derived by taking 1/10th of the most restrictive ALI listed in table 1, columns 1 and 2, of appendix B to §§ 20.1001-20.2401 of this part, rounding to the nearest factor of 10, and arbitrarily constraining the values listed between 0.001 and 1,000 μCi. Values of 100 μCi have been assigned for radionuclides having a radioactive half-life in excess of 109 years (except rhenium, 1000 μCi) to take into account their low specific activity.

Note: For purposes of §§ 20.1902(e), 20.1905(a), and 20.2201(a) where there is involved a combination of radionuclides in known amounts, the limit for the combination should be derived as follows: determine, for each radionuclide in the combination, the ratio between the quantity present in the combination and the limit otherwise established for the specific radionuclide when not in combination. The sum of such ratios for all radionuclides in the combination may not exceed ``1'' (i.e., ``unity'').

This is to acknowledge the receipt of your letter/application dated

6/3/13, and to inform you that the initial processing which includes an administrative review has been performed.

Renew (SUD-157 / 04006329)

- [X] There were no administrative omissions. Your application was assigned to a technical reviewer. Please note that the technical review may identify additional omissions or require additional information.

- [ ] Please provide to this office within 30 days of your receipt of this card

____.

A copy of your action has been forwarded to our License Fee & Accounts Receivable Branch, who will contact you separately if there is a fee issue involved.

Your action has been assigned **Mail Control Number** 581065.
When calling to inquire about this action, please refer to this control number.
You may call us on (610) 337-5398, or 337-5260.

NRC FORM 532 (RI)
(6-96)

Sincerely,
Licensing Assistance Team Leader