



AMERICAN UNIVERSITY OF BEIRUT
Radiation Protection Handbook



University Radiation Safety Committee
&
Health Physics Services Division (EHS&RM)

PREFACE

The American University of Beirut (Campus, Medical Center & AREC) is committed to maintaining a safe environment for its patients, students, visitors, and employees where sources of ionizing radiation are used safely and effectively for medical, research and teaching purposes.

The Health Physics Services (HPS) division of the Environmental Health, Safety & Risk Management (EHSRM) department is responsible for implementing the University Radiation Safety Regulations as prescribed by the University Radiation Safety Committee, local regulations, and rules and regulations equivalent to the US Nuclear Regulatory Commission (NRC), US Environmental Protection Agency (EPA), the US Department of Transportation (DOT), the US National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), and the American Association of Physicists in Medicine (AAPM).

The 2009 edition of the American University of Beirut Radiation Protection Handbook describes the current policies and practices of the University Radiation Safety Committee (URSC) and (HPS). This edition supersedes the previous edition of the handbook.

Since the Handbook will be periodically revised, all concerned personnel are kindly asked to contact HPS (2378, 2360) for any comments or suggestions.

List of Abbreviations

AAPM – American Association of Physicists in Medicine

EHSRM – Environmental Health, Safety & Risk Management

EPA – Environmental Protection Agency

HPS – Health Physics Services

IAEA – International Atomic Energy Agency

ICRP – International Commission on Radiological Protection

LAEC – Lebanese Atomic Energy Commission

NCRP – National Council on Radiological Protection and Measurements

URSC – University Radiation Safety Committee

US NRC – United States Nuclear Regulatory Commission

US FDA – United States Food and Drug Administration

US DoT – United States Department of Transportation

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1 Radiation Protection Program

The Radiation Protection Program described in the Radiation Protection Handbook represents the policies and procedures of the American University of Beirut (AUB) in the field of ionizing radiation and is intended to facilitate and control the use of ionizing radiation sources (***this term will be used in this handbook to refer to Sealed and Unsealed Sources of Radioactive Materials as well as Radiation Producing Equipments***) at AUB (Campus, Medical Center and AREC), in teaching, research and medical applications, and to protect faculty, staff, students, patients and the general public from the potentially harmful effects of ionizing radiation.

1.1 Purpose

This handbook specifies the procedures and requirements pertaining to the procurement, storage, use, and disposal of ionizing radiation sources which shall be applied to reduce, to a level As Low As Reasonably Achievable (ALARA); the amount of radiation to which any person may be exposed. It is intended to guide AUB personnel to prevent causing any individual to be exposed to radiation in excess of the limits defined in this handbook. It contains a series of provisions and recommendations which should be interpreted with scientific judgment in their application to a particular situation.

Any relaxation of the provisions must be approved in writing by the University Radiation Safety Committee at the recommendation of the University Radiation safety officer based on assessment of the possibility of hazard, taking into account the nature of the radiation source, operations and working facilities.

1.2 Scope and Application

The provisions of this code shall apply in all buildings and grounds under the jurisdiction of AUB and shall govern the following:

- All activities in laboratories, classrooms and other places at AUB in which ionizing radiation sources are used.
- All AUB employees who receive, possess, use, handle, store, transfer, or dispose of ionizing radiation sources within University property.
- All persons within AUB who are exposed to ionizing radiation arising within AUB.

1.3 Organization

1.3.1 National License to Possess and Use Ionizing Radiation Sources

The American University of Beirut has applied, in compliance with the Lebanese Laws, for a national license to possess and use ionizing radiation sources. This license is granted by the Ministry of Public Health through the Lebanese Atomic Energy Commission (LAEC).

LAEC, established in 1996 with the support of the International Atomic Energy Agency and the Arab Atomic Energy Commission, governs the use of ionizing radiation sources in Lebanon, and is responsible for the implementation of the Lebanese laws pertaining to this domain.

The Health Physics Services Division (HPS) of the Environmental Health, Safety & Risk Management department (EHSRM) is responsible for ensuring compliance with the

Lebanese Laws and Regulations pertaining to radiation safety and maintaining proper coordination with LAEC.

1.3.2 Organization of the Radiation Protection Program

The radiation protection program is a service that is provided by the Health Physics Services division of the Environmental Health, Safety & Risk Management department, and is controlled by the University Radiation Safety Committee.

Nevertheless, responsibility for radiation safety begins with the individual handling ionizing radiation sources in his/her department/laboratory, and extends upwards through a chain comprising the principal authorized user, the University Radiation Safety Officer, The Environmental Health, Safety & Risk Management Department, the University Radiation Safety Committee, to reach finally the Radiation Oversight Team.

1.3.3 Radiation Oversight Team

The Radiation Oversight Team, which consists of the Vice President for Facilities, the Vice President for Medical Affairs, the Vice President for Finance, and the Provost, monitors the work of the University Radiation Safety Committee. The Radiation Oversight Team delegate authority to the University Radiation Safety Committee to issue regulations and licenses, inspect, and enforce the University radiation safety regulations.

1.3.4 American University of Beirut Radiation Safety Committee

The University Radiation Safety Committee reports to the Radiation Oversight Team and is charged with the responsibility of seeing that all uses of ionizing radiation sources (Radioactive Materials, Radiation Producing Equipments) at the University are in full compliance with Lebanese laws, the University Radiation Safety Regulations and regulations equivalent to the U.S. Nuclear Regulatory Commission, the U.S. Department of Energy, the U.S. Department of Transportation, the U.S. Environmental Protection Agency, the International Commission on Radiological Protection, and the American Association of Physicists in Medicine. The Committee is empowered by the Radiation Oversight Team to take whatever steps are necessary to ensure compliance with these regulations.

The membership of this committee includes representatives from departments where ionizing radiation sources are used, in addition to the University radiation safety officer. A quorum of 50% or more of the voting members is required, including the University radiation safety officer, to conduct business and a majority vote is required to approve a motion.

The committee will formulate the “pertinent regulations” of the American University of Beirut, which shall be approved by the Radiation Oversight Team. The Committee will evaluate all proposed uses of radiation sources. Evaluation criteria considered include, but are not limited to; adequacy of facilities and equipment; operating, handling, and emergency procedures; and the experience and training of the applicant.

The Committee shall meet quarterly, and is asked to provide assistance and advice to members of the University who wish to use ionizing radiation sources in their work according to the Radiation Protection Handbook.

1.3.5 University Radiation Safety Officer

A University Radiation Safety Officer is also required by the AUB Radiation Safety Committee for licensing. The University radiation safety officer has the authority to implement University Radiation Safety Committee and Administration policies, procedures, and regulations. The University radiation safety officer also has the authority to take any action necessary to assure health and safety in the event of an emergency involving ionizing radiation sources. Refer to Chapter 2 for detailed responsibilities of the University Radiation Safety Officer.

1.3.6 Principal Authorized Users

A principal authorized user is an individual (or group) who has been licensed by the URSC to possess and use ionizing radiation sources within specified limits after submitting the corresponding application. ***The license delegates to the user the ultimate responsibility for the safe handling of the radioactive materials or Radiation Producing Equipments.***

2 Regulations of the University Radiation Safety Committee

All possible assistance will be provided by the Committee to the individual user of ionizing radiation sources to assure maximum benefit from such use and to assure radiation protection for staff, patients, visitors, the concerned department, the University, and the community. **HOWEVER, THE ULTIMATE RESPONSIBILITY FOR THE SAFE HANDLING OF IONIZING RADIATION SOURCES IN FULL COMPLIANCE WITH REGULATIONS RESTS WITH THE INDIVIDUAL USER.**

2.1 Licensing

Ionizing Radiation Sources may only be used with the written authorization of the University Radiation Safety Committee. An application for a license must be submitted to HPS and be approved by the Committee before Ionizing Radiation Sources may be ordered and utilization may begin. For more detailed information refer to Chapters 3 and 4.

2.2 Inspection and Enforcement Policy

The University radiation safety officer will inspect each licensed laboratory for compliance with the University Radiation Safety Regulations on a monthly basis.

A compliance checklist will be filled and non-compliances reported to the principal authorized user and to the chairperson of the University Radiation Safety Committee. The University radiation safety officer will specify discrepancy(ies) and schedule a follow up visit. If in the follow up visit the same non-compliance was observed, the department head will be notified and the chairperson of the University Radiation Safety Committee will advise the principal authorized user of sanctions that may include suspension of ionizing radiation sources purchasing privileges, or outright suspension of the license, based on the URSC decision.

2.3 Radiation Safety Orientation

Radiation Safety Orientations are required by the University Radiation Safety Committee (URSC) for every individual prior to assuming responsibilities involving the use of ionizing radiation sources. The Health Physics Services Division (HPS) of EHSRM provides a variety of radiation safety orientations that are specifically tailored to cover all the activities involving the use of ionizing radiation sources at AUB.

It is the responsibility of the principal authorized user to ensure that radiation safety orientations are completed by personnel under his/her jurisdiction. Completion of the orientation involves both attending all the assigned sessions, and scoring 70% or more in the final quiz. Yearly refresher orientations will be provided to users by HPS.

2.4 Procuring Ionizing Radiation Sources

Purchase Requests of ionizing radiation sources, shipments to and from the University, and transfers within the University must be processed through HPS. For more detailed information refer to Chapter 5.

2.5 Storage and Inventory

Ionizing Radiation Sources must be stored in secure areas and in a manner to minimize the risk of breakage, damage, theft, etc. The user must update the HPS inventory forms as applicable.

2.6 Facilities and Equipment

The principal authorized user must ensure that proper facilities and equipment are provided and used as appropriate. This may include items such as disposable workbench liners, disposable gloves, trays, lab coats, work shields, radiation detectors, fume hoods, etc.

2.7 Monitoring, Recording, and Decontamination

Persons using ionizing radiation sources are responsible for conducting routine (as per the terms of their licenses) surveys to detect excessive contamination or exposure. These surveys must be recorded in the Radiation Survey Log provided by HPS. If contamination/exposure in excess of permissible levels is detected, users must notify HPS (ext. 2360). For more detailed information refer to section 5.3.3.

2.8 Personnel Dosimeters (Film Badges)

Personnel dosimeters (film badges, TLD rings, etc.) are provided by HPS, when appropriate, and must be worn as required. For more detailed information refer to section 12.3.

2.9 Exposure Limits and ALARA

Persons using ionizing radiation sources are responsible for preventing exposures in excess of the limits specified in Chapter 11. Furthermore, exposures must be kept As Low As Reasonably Achievable (ALARA) beneath these limits.

2.10 Labeling and Signs

All containers of radioactive material must be labeled with the radiation symbol, the radionuclide, the activity, the date, and chemical composition. HPS will provide signs to post laboratory areas and Radiation Producing Equipments. For more detailed information refer to section 5.2.2.

2.11 Radioactive Waste

The disposal of radioactive waste is both expensive and heavily regulated. Users must follow the regulations in section 5.5.

2.12 Pregnancy Policy

The University Radiation Safety Regulations advise, but do not force the pregnant employee to declare her pregnancy. The pregnant employee is advised to meet with the University radiation safety officer to discuss any additional safety measures that the employee shall apply. For more detailed information refer to Chapter 8.

2.13 Accidents and Emergencies

All accidents and unusual conditions involving ionizing radiation must be reported to HPS. For more detailed information refer to Chapter 10.

3 Licensing Users to Possess and Use Sealed/Unsealed Sources of Radioactive Materials

3.1 Application for possession and use of Sealed/Unsealed Sources of Radioactive Materials

All users of Radioactive Materials (sealed and unsealed) are required to apply for a license to order, possess, use, and transfer these materials. The University provides the administrative controls for the safe and proper use of radiation in agreement with Lebanese law and rules equivalent to the Nuclear Regulatory Commission. This control is provided by the University Radiation Safety Committee and implemented through the Health Physics Services Division of the Environmental Health, Safety & Risk Management department.

All licensed users who wish to use new types of Radioactive Materials, new experimental procedures, or new laboratory locations are required to apply for an amendment of their licenses.

Applications for new licenses or for amendment of old licenses are reviewed during the quarterly meetings of the Committee. To be considered for approval, a license application must be completed by the Applicant and reviewed by the University radiation safety officer at least one month prior to the Committee meeting. **Only after approval by the Committee may the Principal authorized user order, receive, and use radioactive materials** except for the following.

For routine use of small quantities of radioactive materials, the Committee has allowed the University radiation safety officer to temporarily and conditionally approve the license until the Committee meets to consider the application. This allows the applicant to begin research or work without undue delay. The license application must still be submitted by the applicant and reviewed by the URSC before consideration for temporary or final approval. Non-routine use of radioactive materials can only be approved by the Committee. The minimum qualifications for an applicant are previous training and experience in using radiation commensurate with the types and amounts of radioactive materials he or she wishes to use. Inexperienced applicants may gain experience under the supervision of a Committee approved individual. Please contact HPS at x2360 to request an application for a new license or for a license amendment.

3.2 License for Possession and Use of Sealed/Unsealed Sources of Radioactive Materials

Upon approval of the application by the University Radiation Safety Committee, a License for possession and use of sealed/unsealed sources of radioactive materials will be issued. The license will authorize the possession and use of certain radionuclides and chemical forms within certain limits. The license will designate the building and room(s) where the work is to be carried out.

Orders for the purchase or production of radionuclides specified in the license shall then be approved by the University radiation safety officer.

A principal authorized user with a Radioactive Materials License is responsible for the safe handling of all radionuclides he or she receives, including the following: overall supervision of work with radioactive materials, ensuring completion of basic and refresher training by all personnel, ensuring that contamination surveys are performed and properly

documented, ensuring the maintenance of accurate current records of receivings, usage and waste disposal of all Radioactive Materials in his or her possession, and ensuring compliance with all regulations and license commitments. Additionally, the principal authorized user must designate a Laboratory Contact. The Laboratory Contact is responsible for coordinating activities such as contamination clean-up, radioactive waste disposal, and the exchange of dosimeters. Correspondence from Health Physics Services Division regarding laboratory practices will be sent to both the principal authorized user and the Laboratory Contact.

An amendment must be requested for work which differs from that specified in the license. All licenses will be effective for three years. Prior to expiration, the University radiation safety officer, the principal authorized user and the University Radiation Safety Committee will review the license for continued applicability.

In order to ensure the compliance of the laboratory with the terms of the license issued to the Principal authorized user and the University Radiation Safety Regulations, HPS performs periodic undeclared audits of each laboratory. During audits, HPS personnel reviews records, assesses the knowledge of the staff, and completes a radiation safety checklist. Final audit findings are reported to the principal authorized user. Items of non-compliance and other concerns identified during the audit require a written response from the principal authorized user which must include a plan for corrective actions. Refer to section 2.2 for the Inspection and Enforcement Policy.

4 Licensing Users to Possess and Use Radiation Producing Equipments

4.1 Application for possession and use of Radiation Producing Equipments

All users of Radiation Producing Equipments (RPE) are required to apply for a license to order, possess, use, and transfer RPE. The University provides the administrative controls for the safe and proper use of radiation in agreement with Lebanese law and rules equivalent to the NRC, NCRP, AAPM. This control is provided by the University Radiation Safety Committee and implemented through the Health Physics Services Division of the Environmental Health, Safety & Risk Management department.

All licensed users who wish to order/use new Radiation Producing Equipments are required to apply for an amendment of their license.

Applications for new licenses or for amendment of old licenses are reviewed during the quarterly meetings of the Committee. To be considered for approval, a license application must be completed by the Applicant and reviewed by the University radiation safety officer at least one month prior to the Committee meeting. **Only after approval by the Committee may the Principal Authorized User order, receive, and use Radiation Producing Equipments** except for the following.

For routine use of Radiation Producing Equipments, the Committee has allowed the University radiation safety officer to temporarily and conditionally approve the license until the Committee meets to consider the application. This allows the applicant to begin research or work without undue delay. The license application must still be submitted by the applicant and reviewed by the URSC before consideration for temporary and/or final approval. Non-routine use of Radiation Producing Equipments can only be approved by the Committee.

The minimum qualifications for an applicant are previous training and experience in using radiation commensurate with the type of the Radiation Producing Equipment(s) listed in the license. Inexperienced applicants may gain experience under the supervision of a Committee approved individual. Please contact HPS at x2360 to request an application for a new license or for a license amendment.

4.2 License for Possession and Use of Radiation Producing Equipments

Upon approval of the University Radiation Safety Committee, a license to possess and use Radiation Producing Equipments will be issued to the Principal Authorized User. The license will authorize the possession and use of certain RPE within certain limits. The license will designate the building and room(s) where the work is to be carried out.

A principal authorized user with a License to Possess and Use Radiation Producing Equipments is responsible for the safe handling of all RPE he or she possesses, including the following: overall supervision of work with RPE, ensuring completion of basic and refresher training by all personnel, ensuring that Quality Control Tests are performed and properly documented as per the University procedures, maintaining accurate records of On-Time when applicable, and ensuring compliance with all regulations and license commitments. Additionally, the principal authorized user must designate a Department Contact. The Laboratory Contact is responsible for coordinating activities such as exchange of dosimeters. Correspondence from Health Physics Services Division regarding laboratory practices will be sent to both the principal authorized user and the Laboratory Contact. A

licensed operator or his or her responsible, trained assistant must be present whenever a Radiation Producing Equipment is in operation.

An amendment must be requested for work which differs from that specified in the license. All licenses will be effective for three years. Prior to expiration, the University radiation safety officer, the principal authorized user and the University Radiation Safety Committee will review the license for continued applicability.

In order to ensure the compliance of the laboratory with the terms of the license issued to the Principal authorized user and to the University Radiation Safety Regulations, HPS performs periodic undeclared audits of each laboratory. During audits, HPS personnel reviews records, assesses the knowledge of the staff, and completes a radiation safety checklist. Final audit findings are reported to the principal authorized user. Items of non-compliance and other concerns identified during the audit require a written response form the principal authorized user which must include a plan for corrective actions. Refer to section 2.2 for the Inspection and Enforcement Policy.

5 Use of Ionizing Radiation Sources – General

The General University Radiation Safety Regulations pertaining to the possession and use of ionizing radiation sources (sealed and unsealed sources of radioactive materials as well as radiation producing equipment) are set forth in this chapter.

5.1 Purchase/Transfer of Radioactive Materials

Ionizing radiation sources may be purchased, used, moved, or stored at the University only with authorization by the University Radiation Safety Committee. Refer to Chapter 3 or 4 for licensing procedures. This section attends to the University Radiation Safety Regulations pertaining to the purchase and transfer of ionizing radiation sources.

5.1.1 Purchase of Radioactive Materials

The steps to follow by principal authorized users in order to purchase sources of ionizing radiation are the following:

- Fill and sign the form required by the Lebanese Atomic Energy Commission to license the provider to import the requested ionizing radiation source. This form is available at the Health Physics Services Office.
- Submit the form to HPS; the form will be reviewed and submitted to the concerned provider after approval.
- Place a Purchase Request (PR) online to be processed by the Purchasing department after approval by HPS.

This applies to both routine purchase orders and when setting up standing purchase orders. The description of the radioactive material must include the radionuclide, the total activity being ordered, the chemical description, and any other pertinent data.

The shipment must be addressed to, and received by, the HPS. Upon receiving, the shipment will be opened and examined for proper packaging, damage, and contamination. The shipment will then be recorded in the Radioactive Materials Inventory and delivered to the user if the material will not cause the license limits to be exceeded. If a limit was exceeded, a license amendment will be required to avoid delay in delivery. Any adjustments, replacements, or special handling will be performed only with the consent of HPS. Refer to Appendix K for more details about the “Receiving of Radioactive Materials” procedure.

5.1.2 Free-of-Charge Items and Loans of Radioactive Materials

Any radioactive material which is received by any faculty or staff member for use at the University at no cost to the University will be considered as a free-of-charge item. Any radioactive material which is received by any faculty or staff member on loan from any source outside the University will be considered as a loan. Before intended receiving of any free-of-charge items or loans of radioactive materials, the licensee must notify HPS. If unlicensed, a Radioactive Materials License must be obtained. The shipment must be addressed to, and received by, HPS.

5.1.3 Purchased or Free-of-Charge Radiation Producing Equipments

HPS must be notified in advance of intent to purchase, sell, move, give or receive a Radiation Producing Equipment as a free-of-charge item or loan. This advance notice allows HPS an opportunity to address any radiation safety concerns and to ensure that the machine is properly registered with the University Radiation Safety Committee.

5.1.4 Transfers of Radioactive Materials

Transfers of all sealed and unsealed sources of radioactive materials to and from the American University of Beirut, to and from any branch of the University, to and from separate buildings, and to and from separate laboratories shall be arranged through HPS to ensure safe handling and transport. The University radiation safety officer must approve all transfers and record them prior to movement. Transfers may only take place between appropriately licensed locations.

Packages of radioactive materials shipped from the University via local or U.S. Mail, common carrier, or private vehicle must be packaged, labeled, and certified in accordance with international transportation regulations. HPS will assist the principal authorized user with the proper packaging, labeling, and certification of shipments of radioactive materials. Refer to Appedix L for more details about the "Transfer of Radioactive Materials" procedure.

5.1.5 Equipment Transfer/Disposal Surveys

Equipment used with or for storing open sources of radioactive materials (such as refrigerators, centrifuges, and other laboratory items) shall be surveyed by HPS prior to transfer or disposal. It is the responsibility of the principal authorized user to notify HPS about such action ahead of time in order for HPS staff to perform the necessary survey. Survey results will be recorded and copies shall be kept with the concerned department.

Equipment containing sealed or unsealed radioactive source (Liquid Scintillation Counter, ^{99}Mo - $^{99\text{m}}\text{Tc}$ generator, ...) shall have the source and any lead shielding removed prior to disposal. Radiation Producing Equipments shall have the X-Ray tube removed and/or destroyed prior to disposal. All radioactive signs and symbols must be eliminated or removed.

5.2 Caution Signs and Labels

All signs and labels required by this section must bear the conventional radiation symbol in magenta or black on a yellow background. Signs and labels will be supplied by HPS. Adhesive tape bearing the radiation symbol is available at HPS.

IMPORTANT: RADIATION WARNING TAPE AND SIGNS MUST NOT BE USED INDISCRIMINATELY IN NON-RADIATION APPLICATIONS. SUCH USE CONVEYS A FALSE WARNING, WHICH MAY BREED DISRESPECT FOR REAL HAZARDS. THIS PRACTICE IS EXPRESSLY FORBIDDEN BY REGULATIONS.

5.2.1 University Area/Room Posting

Each area or room in which an ionizing radiation source is used or stored must be conspicuously posted with a sign, or signs, bearing the radiation caution symbol and the words, "CAUTION RADIOACTIVE MATERIALS" in both Arabic and English.

Each “Radiation Area” must be conspicuously posted with a sign bearing the radiation caution symbol and the words, “CAUTION RADIATION AREA” in both Arabic and English. A “Radiation Area” is defined by the US Nuclear Regulatory Commission as “any area accessible to individuals, with radiation levels greater than 0.05 mSv (5 mrem) in one hour at 30 centimeters from the source or from any surface through which the radiation penetrates.”

Each “High Radiation Area” must be conspicuously posted with a sign bearing the radiation caution symbol and the words, “CAUTION HIGH RADIATION AREA” in both Arabic and English. A “High Radiation Area” is defined by the US Nuclear Regulatory Commission as “any area accessible to individuals, with dose rates greater than 1 mSv (100 mrem) in one hour at 30 centimeters from the source or from any surface through which the radiation penetrates.” HPS must be notified in advance of any potential high radiation areas so that proper precautions may be implemented.

Each “Very High Radiation Area” must be conspicuously posted with a sign bearing the radiation caution symbol and the words, “GRAVE DANGER, VERY HIGH RADIATION AREA” in both Arabic and English. A “Very High Radiation Area” is defined by the US Nuclear Regulatory Commission as “an area accessible to individuals, in which radiation levels exceed 5 Gy (500 rad) in one hour at 1 meter from the source or from any surface through which the radiation penetrates.” HPS must be notified in advance of any potential high radiation areas so that proper precautions may be implemented.

Each area or room in which radioactive materials are dispersed in the air in the form of dusts, mists, vapors, or gases must be conspicuously posted with a sign bearing the radiation caution symbol and the words, “CAUTION, AIRBORNE RADIOACTIVITY AREA” in both Arabic and English. HPS must be notified in advance of any potential airborne radiation areas so that proper precautions may be implemented.

Each area or room in which x-ray machines are permanently installed must be conspicuously posted with a sign bearing the radiation caution symbol and the words “CAUTION X-RAY EQUIPMENT” in both Arabic and English.

5.2.2 Labels

Each container of radioactive material must be clearly labeled with a durable, clearly visible label that identifies the contents of the container. The label must bear the radiation caution symbol, the words, “CAUTION RADIOACTIVE MATERIAL”, and the radionuclide, total activity, chemical composition, and the date. In addition, all laboratory equipment such as; centrifuges, water baths, etc., and that are used to handle Radioactive Materials should be labeled and should be used ONLY with Radioactive Materials.

A label is not required on a container when it is continuously attended by the responsible user.

5.2.3 Labeling of Radiation Producing Equipments

Each radiation machine must be labeled with a sign bearing the radiation caution symbol and the words, “CAUTION X-RAYS, THIS EQUIPMENT PRODUCES X-RAYS WHEN ENERGIZED.”

5.3 Operating Procedures and Techniques

Certain safety precautions are necessary to control external and internal exposure to radiation. Time, distance, and shielding are easily used to control external exposure.

Contamination control and proper ventilation are used to limit ingestion, inhalation, and absorption.

5.3.1 Engineering Controls

Operations with powdered, volatile, or gaseous radioactive materials, or any other process that could lead to production of airborne radioactivity, must be performed in an adequately ventilated fume hood (125 ft./min. face velocity) or a glove box.

5.3.2 Personnel Protective Measures – Unsealed Sources of Ionizing Radiation

EATING, DRINKING, AND SMOKING ARE PROHIBITED IN ANY LABORATORY.

Pipetting by mouth suction is prohibited in any area or process where radioactive materials are used. Putting any potentially contaminated object into the mouth with potentially contaminated fingers is considered an unsafe practice. Eye protection must be worn in all laboratories where there is a possibility of eye injuries.

Protective gloves should be worn during all handling operations where contamination is a potential hazard. After use, disposable gloves should be discarded in the solid radioactive waste container. After removing protective gloves, the hands should be thoroughly washed with both soap and water, dried, and checked for radioactive contamination with a laboratory monitor. Protective gloves are not only intended to protect the worker's hands, but also to prevent the spread of contamination. When working with radioactive materials, never touch a contaminated surface with bare hands, or a clean surface with potentially contaminated gloves. If you know, or suspect, your gloves are contaminated, discard them and put on new gloves. Working with contaminated gloves is one of the major sources of laboratory contamination. CHANGE DISPOSABLE GLOVES FREQUENTLY.

Try out all new procedures and manipulations by practicing with non-radioactive materials.

A Geiger Mueller counter or appropriate radiation detector should be used when working with penetrating radiation such as high energy beta or gamma radiation.

When working with energetic beta or gamma radiation, with large quantities (greater than 74 MBq (2 mCi) of radionuclides, or when long periods of time will be spent near an isotope, remote handling devices should be used.

Radiation shielding should be used whenever practical to minimize exposure.

The time required to handle any container of radioactive material should always be kept to minimum.

If, in the course of work, personal contamination is suspected, a survey with a suitable instrument (or a wipe test) shall be made immediately by the user. HPS personnel shall be notified immediately. If personal contamination is found, refer to section 10.2.

HPS must be notified prior to the initiation of any experiment that requires the use of respirators. Respirators may not be used in a routine manner. Any experiment that requires respiratory protection should be conducted in a properly operating fume hood. EHSRM maintains a respirator fit testing program. Call x2360 to be fit tested for a respirator.

All personnel who are required to stand beside the patient while operating a Radiation Producing Equipment shall wear appropriate lead aprons. Lead glasses, and lead shields shall be used when needed.

5.3.3 Monitoring, Recording, and Decontamination

Laboratory contamination surveys of all potentially contaminated surfaces should be performed **by the user at the end of each work day or after each procedure, whichever is more frequent**. Refer to Appendix H for more details about the contamination surveys procedure. The performance of these surveys is required to detect any contamination resulting from radiation work in order to limit radioactive contamination of work areas and occupational exposure to personnel.

HPS will provide Radiation Survey Log in which to record the results. Contamination should be recorded as disintegrations per minute per 100 square centimeters of area wiped. Decontamination is required for any area where the level of contamination exceeds three times the background radiation level.

It is much easier to prevent the spread of contamination than it is to decontaminate an area. If practical, the use of radioactive materials should be confined to a designated part of the lab to minimize the survey and cleanup area. Bench tops and other work areas should be covered with absorbent, plastic backed paper and trays should be used if liquid is involved. The absorbent paper should be disposed of immediately after completion of the experiment. To leave the paper in place is to preserve the contamination for later dispersal. After working with large quantities of radioactive materials, it is a good practice to clean the bench tops, even before the presence of contamination is confirmed. **RADIATION WORKER MUST ASSUME THAT CONTAMINATION IS PRESENT UNTIL HE HAS PERFORMED A THOROUGH SURVEY WHICH PROVES THAT THE AREA IS CLEAN.**

In order to avoid the spread of contamination, extra care must be taken when washing glassware and other items of equipment that have come into contact with radioactive materials. It is recommended that disposable supplies and equipment be used whenever it is practical. Otherwise, highly contaminated items should be washed separately from slightly or potentially contaminated items. Since the University does not allow sink disposal (exceptions are given by the HPS), the wash water should be placed in a liquid radioactive waste container. After these highly contaminated items have been separately washed to reduce the level of contamination, they should be washed again with the slightly contaminated items. Care should be exercised when pouring dilute rinse water down the sink drains. Contaminated sinks can result in the spread of radioactive contamination back into the laboratory, as well as out into the environment. If sinks are found to be routinely contaminated, this is an indication that some liquid wastes are being poured down the drain, when they should be placed in the liquid radioactive waste container.

If a spill or other release of radioactive material occurs, call HPS on extension x2360 immediately, regardless of the spill or release. After hours, HPS may be reached by calling the Protection office at x2400. Please do not hesitate to call HPS at any time to report a spill or other radiation safety problem. ***There are no consequences for prompt reporting. However, the consequences of late reporting, or no reporting, may be severe.***

HPS will perform additional monthly contamination surveys in all laboratories where open sources of radioactive materials are used. HPS will also perform radiation survey log audits on a monthly basis.

5.4 Storage of Radioactive Materials

Radioactive materials must be stored in a location accessible only to authorized persons. Unauthorized transfer or removal of any radioactive materials from any building, or from the University, is prohibited. The storage container must be labeled with the radionuclide, total activity, date, chemical form, and name of the responsible person. Freezers or other storage locations used to store radioactive materials must bear the "Caution! Radioactive Materials" sign or label. Only Storage areas approved in the individual license shall be used. These storage areas shall be properly and conspicuously labeled.

5.4.1 Shielding

Radioactive materials in storage must be shielded such that radiation dose equivalent rates in adjacent, accessible areas are less than 20 μSv (2 mrem) per hour. High energy beta emitting radionuclides such as ^{32}P should be stored in shields constructed of low atomic number materials such as Lucite. Low Z materials are good absorbers for beta radiation, and produce a minimum of bremsstrahlung x-rays.

5.4.2 Tritium Contamination of Freezers

When tritium labeled compounds, in any type of container other than a sealed glass ampoule, are stored in a freezer, radioactive contamination will appear in the frost accumulation in concentrations up to several microcuries per milliliter of frost melt. When defrosting freezers in which radioactive materials are stored, the frost melt must be considered liquid radioactive waste, and must be disposed of as specified in section 5.5.2. In frost free freezers, tritium may adhere or adsorb onto the surfaces of the freezer. All freezers where ^3H is stored are checked by HPS regularly for excessive contamination. Refer to the HPS standard operating procedures manual for more details about the "Freezers Inspection for Contamination with Tritium" procedure.

5.4.3 Flammable Liquids

Flammable organic solvents must not be stored in refrigerators or freezers with radioactive materials. A small spark from internal thermostats or lights can cause flammable vapors to explode. Special explosion proof refrigerators and freezers are required to avoid this hazard. Call EHSRM at extension x2360 for further information.

5.5 Radioactive Waste Disposal

NO RADIOACTIVE WASTE IS TO BE DISPOSED OF, BY UNAUTHORIZED PERSONNEL, VIA THE PUBLIC LANDFILL, THE SANITARY SEWER, OR RELEASED TO THE ENVIRONMENT.

Radioactive waste must be segregated by waste type (Solid, Liquid, and scintillation vials) and by Half-Life (Short lived, and long lived). It is the responsibility of the principal authorized user to provide HPS with accurate information of the protocols that will take place in his/her laboratory in order for HPS to equip the laboratory with the necessary waste containers.

Only biodegradable scintillation liquids are allowed to be used at the University in order to limit the production of mixed waste (chemical and radioactive). HPS has a list of accepted scintillation fluids.

Radioactive waste must be packaged according to the methods of this section to ensure compliance with the University radiation safety regulations and permit safe disposal. If

wastes are improperly packaged or labeled, HPS will not pick up the waste until the problem is corrected. The disposal information tag on each container must be fully completed. All properly packaged radioactive wastes may be disposed of by calling HPS at x2360. Refer to the HPS standard operating procedures manual for more details about the “Radioactive Waste Disposal” procedure.

5.5.1 Solid Radioactive Waste

The term “solid waste” includes **dry** solid or powdered radioactive materials, dehydrated biological materials, and contaminated paper, plastic, glassware, gloves, apparel, etc. Solid dry waste includes materials either known or suspected to be contaminated with radioactive materials.

Other types of radioactive waste must NOT be disposed of in the dry solid containers. Biohazardous materials or equipment used to handle such material (syringe needles, test tubes, capillary tubes, etc.) must be rendered biologically harmless and packaged according to section 5.5.4. Liquid scintillation vials must be packaged according to section 5.5.3, and carcasses of dead animals must be packaged according to section 5.5.4. In addition, Lead pigs, sharps (razor blades, syringes, pasteur pipettes, scalpel blades, etc.), liquid containers with greater than 10ml of liquid, may not be disposed of in the solid waste containers. The liquid shall be emptied into the liquid waste container provided. Appropriate containers are provided for each of these excluded wastes. Empty lead pigs are collected by HPS upon the request of the generating department.

5.5.2 Aqueous Liquid Radioactive Waste

The term “aqueous liquid waste” includes liquid radioactive waste materials, solutions, contaminated rinses, etc. Aqueous waste may not contain biohazardous materials. Liquids such as liquid scintillation fluids are not aqueous waste and must be disposed of separately according to section 5.5.3.

All aqueous liquid wastes shall be disposed of in marked radioactive waste containers provided by HPS. Liquid containers must not be filled beyond the base of the neck. Due to the high costs of waste disposal by volume, liquid wastes should not be intentionally diluted with non-radioactive liquids.

5.5.3 Liquid Scintillation Vials

Radioactive liquid scintillation solutions must be disposed of in the vials in which they were counted. Scintillation vials must be segregated according to radionuclide group. Vials containing only ^3H or ^{14}C should be disposed of separately from all other radionuclides. Only nontoxic biodegradable scintillation fluids are allowed for use.

5.5.4 Biological Radioactive Waste

Waste containing pathogenic, infectious, or otherwise biohazardous material or equipment used to handle such material (syringes, test tubes, capillary tubes, etc.) must be rendered biologically harmless using disinfecting agents before disposal as radioactive waste. The equipment rendered non-infectious should be packaged separately from other biological material. Contact HPS at 2360 in advance to make arrangements. **When radioactive material is involved, use of an autoclave is NOT permitted.**

Animal carcasses, solid excreta, organs, etc. (exclusive of small insects or other easily dehydrated biological materials) must be sealed in a plastic bag and labeled with the radiation symbol, the radionuclide, the activity, and the date. Upon completion of the above waste preparation, the waste must be immediately frozen. The waste must be kept frozen until HPS is notified and the waste is removed from the lab. If a freezer is not available, Health Physics Services must be notified in advance so that prompt collection for freezing and/or disposal may occur.

Plant materials may be included in solid waste if dehydrated prior to inclusion.

Suspensions of deactivated microorganisms may be included in liquid waste if concentrations are sufficiently low as to readily permit re-suspension, and if a quantity of antimetabolite sufficient to minimize decomposition is added. Higher concentrations must be separated, as by filtration, and the organic material dehydrated prior to inclusion in solid waste or frozen for disposal as solid biological waste.

Under certain conditions, liquid blood treated with an anticoagulant prior to disposal and animal urine may be included in the aqueous liquid radioactive waste. Contact HPS in advance to make appropriate arrangements.

5.5.5 Waste Requiring Shielding

Penetrating beta and gamma emitting radioactive waste must be shielded by appropriate shielding materials and stored in a manner to prevent exposure to personnel in excess of the limits specified in Chapter 11 and in accordance with the As Low As Reasonably Achievable (ALARA) concept. Radioactive materials must also be stored in a manner to prevent access by unauthorized persons.

5.5.6 Mixed Waste

Radioactive materials or waste that contain hazardous chemicals are considered mixed wastes. These types of materials require extraordinary measures and/or in some cases it may prove impossible to dispose of these mixed wastes. An example of waste that cannot be disposed of, is Uranyl Acetate mixed with organic solvents. There are no viable disposal routes open to the University for the disposal of this type of waste. Contact HPS prior to the generation of this type of waste.

5.5.7 Sealed Sources

Short-lived sealed sources of radioactive materials will be stored in the HPS waste rooms until decay to exempt limits, and will then be disposed as regular waste. Long-lived sealed sources of radioactive wastes will be stored in the HPS waste rooms until proper disposal routes become available. To dispose of sealed sources contact HPS.

5.5.8 Non-radioactive Chemical Waste

Call EHSRM at extension x2360 for collection and disposal of all non-radioactive chemical wastes, including acids, bases, solvents, carcinogenic materials, etc.

5.6 Data on Commonly Used Radioisotopes

Inhalation, ingestion, and absorption of radioactive material must be controlled to prevent internal radiation from all radionuclides. To minimize absorption, surface contamination must be controlled as outlined in section 10.1. Prevention of internal contamination is

described in section 11.2. This applies to all radioactive materials and those categories listed below.

5.6.1 Low-Energy Beta Emitting Radionuclides

Some common radionuclides emitting only beta radiation at energies below 250 KeV are listed in the following table:

Nuclide	Maximum Beta Particle Energy	Average Beta Particle Energy	Physical Half-life
³ H	18 KeV	6 KeV	12.3 years
¹⁴ C	156 KeV	50 KeV	5730 years
³⁵ S	167 KeV	49 KeV	87.9 days
⁴⁵ Ca	252 KeV	75 KeV	165 days

Any standard glass, plastic, or metal container will completely absorb these low energy beta particles. Thus, when in any type of container, they do not present an external radiation hazard.

Due to the low penetrating ability of the radiation, it is difficult to detect these radionuclides with a portable survey instrument. A thin window (1.4 – 2.0 mg/cm²) Geiger counter cannot detect ³H, and is not recommended for ¹⁴C and ³⁵S due to a very low efficiency. The thin window detector would be suitable for ⁴⁵Ca as long as a correction is made for low efficiency. For detecting removable contamination, wipe smears counted with a liquid scintillation counter (LSC) give excellent results.

5.6.2 High-Energy Beta Emitting Radionuclides

Some common radionuclides emitting only beta radiation at energies above 500 KeV are listed in the following table:

Nuclide	Maximum Beta Particle Energy	Average Beta Particle Energy	Physical Half-life
³² P	1.710 MeV	0.690 MeV	14.3 days
³⁶ Cl	0.714 MeV	0.236 MeV	308,000 years
⁹⁰ Sr	0.546 MeV	0.180 MeV	27.7 years
⁹⁰ Y	2.270 MeV	0.930 MeV	64.2 hours
²⁰⁴ Tl	0.756 MeV	0.255 MeV	3.81 years

Any standard glass or metal container will absorb all but the most energetic beta particles from nominal amounts of these radionuclides (i.e. beta particles with energies above 1MeV may penetrate the container). As higher energy beta particles are absorbed, secondary radiation known as bremsstrahlung, or braking radiation, will appear in the form of x-rays. For ³²P, typically less than 1% of the beta decays will result in bremsstrahlung radiation which will penetrate the container. Higher energy beta emitting radionuclides should be stored behind shields constructed of low atomic number materials, such as Lucite, to minimize bremsstrahlung production.

Due to the penetrating ability of the radiation, these radionuclides can be easily detected with a portable survey instrument such as a thin window (1.4 – 2.0 mg/cm²) Geiger counter.

For detecting removable contamination, wipe smears counted with a liquid scintillation counter (LSC) give excellent results.

5.6.3 Beta-Gamma-Emitting Radionuclides

Most other radionuclides commonly used emit both beta particles and gamma rays. The maximum and average beta particle energies, the primary gamma ray energies, and the radioactive half-life of several radionuclides are given in the following table:

Nuclide	Maximum Beta Particle Energy	Primary Gamma Ray Energies	Physical Half-life
²² Na	0.54 MeV	1.28 MeV	2.62 years
⁵¹ Cr	---	0.32 MeV	27.7 days
⁶⁰ Co	0.31 MeV	1.17, 1.33 MeV	5.26 years
⁶⁵ Zn	0.32 MeV	1.12 MeV	245 days
^{99m} Tc	---	0.141 MeV	6.05 hours
Nuclide	Maximum Beta Particle Energy	Primary Gamma Ray Energies	Physical Half-life
¹²⁵ I	---	0.035 MeV	60 days
¹³¹ I	0.61 MeV	0.3664 MeV	8 days
¹³⁷ Cs	0.51 MeV	0.662 MeV	30 years
¹⁴⁴ Ce	0.31 MeV	0.134 MeV	248 days
²¹⁰ Pb	0.061 MeV	0.047 MeV	22 years
²¹⁰ Bi	1.16 MeV	---	5 days
¹⁹² Ir			

The shielding necessary for the beta radiation is described in sections 5.6.1 and 5.6.2. Gamma rays have a much greater penetrating ability. These are best shielded with thicker, denser materials, such as concrete, steel, or lead.

Due to the penetrating ability of the radiation, these radionuclides can be easily detected with a portable survey instrument such as a thin window Geiger counter. For detecting removable contamination, wipe smears counted with a liquid scintillation counter (LSC) give excellent results.

The radiation exposure dose rates can be very high (in the order of tens of mSv/hour) near beta-gamma emitting sources of millicurie or greater activities. Such sources be labeled and posted as specified in section 5.2. High activity sources must never be touched directly with the hands. Remote handling tools, such as tongs or forceps, must be used.

The distance between the sources and the user should be a maximum consistent with the type of operation being conducted. Handling time must be kept to a minimum.

5.6.4 Alpha Emitting Radionuclides

Alpha particles are emitted by many of the radioactive isotopes of the heavy elements. The alpha emission is usually coincident with gamma rays. The primary alpha particle and gamma ray energies, and the radioactive half-life of several radionuclides are given in the following table:

Nuclide	Maximum Beta Particle Energy	Primary Gamma Ray Energies	Physical Half-life
²¹⁰ Po	5.30 MeV	---	138 days
²²⁶ Ra	4.78 MeV	0.187 MeV	1602 years
²²⁸ Th	5.42, 5.34 MeV	0.048 MeV	1.91 years
²³² Th	4.00 MeV	0.060 MeV	1.4E10 years
²³⁸ U	4.19 MeV	0.05 MeV	4.5E09 years
²³⁹ Pu	5.15, 5.14 MeV	0.51, 0.3 MeV	24110 years
²⁴¹ Am	5.48, 5.44 MeV	0.60 MeV	432 years

Alpha particles are completely absorbed by about one inch of air at STP; thus, they present no external radiation hazard. However, if alpha emitting radionuclides are present inside the body, they may be a serious hazard.

Alpha emitters can be detected with a portable survey instrument equipped with an alpha scintillation detector. Because of the short range of alpha particles in air, the detector should be held within 1/8" to 1/4" from the source. For detecting removable contamination, wipe smears counted with a liquid scintillation counter (LSC) give excellent results.

Alpha-gamma emitting radionuclides should be handled the same as beta-gamma emitting radionuclides. Refer to section 5.6.3.

5.6.5 Neutron Sources

There are no radionuclides that emit neutrons directly, with the exception of spontaneous fission of some radioisotopes of heavy elements. There are, however, a number of nuclear processes in which neutrons are produced indirectly. The most common one is the alpha-neutron reaction with beryllium. Nuclear gauges use this reaction to generate neutrons. The alpha source, half-life, and neutron yield for some common alpha-neutron sources are given in the following table:

Neutron Source	Half-life	Yield (neutron/sec/curie)
²⁴¹ Am-Be	432 years	2.7E06
²¹⁰ Po-Be	138 days	2.5E06
²²⁶ Ra-Be	1620 years	(1.0 to 1.5) E07
²³⁹ Pu-Be	24110 years	2.2E06

All alpha-neutron sources emit gamma rays either coincident with the alpha emission, or as a result of the alpha-neutron reaction. Thus, neutron sources should be handled the same as beta-gamma emitting radionuclides.

The gamma emission can be detected using a Geiger counter or ion chamber, but these survey instruments do not detect neutrons. Special survey instruments using BF₃ and LiF are available for detecting neutrons.

6 Use of Radiation – Instructional Programs

Radioactive materials may be frequently used in instructional programs to demonstrate or explain new techniques, or concepts. Students must first successfully complete the radiation safety training that is provided by the HPS before they are allowed to use or handle radiation.

6.1 Use of Sealed or Plated Radioactive Sources

Sealed or plated radioactive sources may present an external exposure hazard but are not a contamination hazard under normal conditions. It is recommended to remotely handle sealed sources of radioactive materials with forceps, tongs, etc., and the handling time must be kept to a minimum. Remote handling tools range in length from about 10 cm to 1 m. A general rule to follow is: The greater the activity, the longer the remote handling tool. When handling radioactive sources, one should hold them away from the body, and never near the eyes. Sources must never be carried around in a pocket.

Depending upon the type of radiation and the activity, there are specific procedure that must be carried out to properly use a sealed source and sign out. Each storage area will have a sign-out form, with instructions, that must be completed. At the end of each laboratory period, radioactive sources must be returned to their normal storage location and secured. The laboratory instructor must verify that all sources are present and accounted for.

Some equipment such as Gas Chromatographs usually contain small sealed sources such as ^3H , ^{63}Ni , ... these equipment usually have a label indicating the presence of such sources and are leak tested by HPS semi-annually to ensure that no leakage of radioactive materials is taking place. If the source was found to be leaking at a level equal or exceeding $0.005 \mu\text{Ci}$, the equipment must be taken out of service for repair or disposal. This source must be removed from the machine prior to disposal.

6.2 Use of Unsealed Radioactive Materials

Most liquid radioactive materials used are ^3H , ^{14}C , ^{32}P , and ^{35}S labeled organic compounds in solution form. In addition to the general regulations outlined in Chapter 5, the following regulations apply to the use of liquid radioactive materials:

To avoid the possibility of cross contamination, no unnecessary personal materials are to be brought into the laboratory. Leave such items outside the lab.

All work in the laboratory must be performed under the supervision of the laboratory instructor, and in accordance with standard, approved laboratory procedures. HPS will provide extra waste containers upon request.

At the completion of each laboratory exercise, the instructor must perform a wipe smear survey, and record the results in the Radiation Safety Survey Log. In addition, the laboratory instructor must call HPS at the completion of each laboratory exercise, so that a check-up contamination survey may be performed.

7 Biological and Chemical Use of Radioactive Materials

In addition to the general regulations outlined in Chapter 5, the following regulations apply to the biological and chemical use of radioactive materials.

7.1 Administration of Radioactive Materials to Animals

Radioactive materials are to be administered only to animals that are owned by the AUB and only as authorized by the University Radiation Safety Committee and the Institutional Animal Care and Use Committee (IACUC).

Animals that have been given radioactive materials must be caged separately from other animals. Cages must be labeled with the appropriate warning signs. The radionuclide, activity, date of administration, and name of the person responsible must be given on the label. If the isotope and quantity administered are such that significant quantities of radioactivity are released during animal respiration, metabolic cages fitted with suitable filters may be required.

Arrangements must be made in advance for the collection of radioactive excreta, so as to minimize contamination of cages and surrounding areas. Dead radioactive animals and radioactive excreta are considered biological radioactive waste, and must be disposed of in accordance with the regulations specified in Section 5.5.4.

7.2 Biochemical Procedures and Airborne Radioactivity

Chemical reactions or radioactive decay may produce radioactive gases, e.g. ^{125}I and ^{131}I released from acid solutions, or noble gases, such as radon, krypton, and argon. Other gases that may be produced by chemical reactions are $^{14}\text{CO}_2$, $^{35}\text{SO}_2$, $^3\text{H}_2$, and $^3\text{H}_2\text{O}$ vapor. Biological metabolism by plants or animals may produce $^{14}\text{CO}_2$ and $^3\text{H}_2\text{O}$. Ion exchange may also occur, e.g. ^3H exchange with ^2H in the atmosphere.

Biological and chemical procedures that may release airborne radioactivity must be performed in an adequately ventilated fume hood (125 ft./min. face velocity) or a glove box. Respirators or self-contained breathing apparatus may also be required for some operations. Estimates of quantities that may be released to the environment must be provided in the radioactive materials license or amendment application.

Some airborne radioactive materials, such as radioiodine vapor or tritiated water vapor, can be absorbed directly through the skin, resulting in internal contamination. The use of an adequate fume hood and personal protective equipment such as a long-sleeved lab coat and disposable double gloves will usually keep absorption through the skin to a minimum. Bioassays may be required. For more information about personnel monitoring refer to sections 12.3.2 and 12.3.3.

7.3 Labeled Nucleic Acid Precursors

Labeled nucleic acid precursors, especially those labeled with ^3H and ^{14}C , present a particular hazard. Because deposition in the human body is not uniform, the biological elimination of these compounds is quite different from those of $^3\text{H}_2$ or $^3\text{H}_2\text{O}$, and the areas of deposition are usually radiosensitive. Insufficient information is available to accurately determine the hazard, but tritiated nucleic acid precursors are estimated to be 1,000 to 1,000,000 times more hazardous than $^3\text{H}_2$ or $^3\text{H}_2\text{O}$ because of their incorporation into the genetic material, DNA. Since detection of ^3H contamination depends upon liquid

scintillation counting of wipe smear tests and a considerable delay in obtaining survey results, the safety of operations dealing with these materials depends almost entirely upon strict observation of precautions and regulations.

7.4 Sealed Sources

In addition to the general regulations outlined in Chapter 5, the following regulations apply to the use of radioactive sealed sources, including nuclear gauges. Radioactive sealed sources are found not only in identified check sources, but they are also found in Electron Capture Detectors contained within gas chromatographs; liquid scintillation counters also contain radioactive sources.

The proper procedures for the safe use of sealed sources depend upon the type of radiation and the activity of the source. Refer to section 6.1 for proper handling technique of sealed sources.

Sealed sources can be separated in two categories; exempt and nonexempt sources. Exempt sources, because of their radiation type and activity are “exempt” from certain regulations governing radioactive waste disposal. These sources are still radioactive and must be used with care. Prior to their use within a contiguous area for example within the DTS building, each researcher must simply complete an entry on the appropriate sign-out sheet.

Non-exempt sources require exacting inventory control, periodic contamination checks, and careful handling procedures. Prior to their use within a contiguous area, for example within the DTS building, each researcher must simply complete an entry on the appropriate sign-out sheet.

Should a researcher desire to transfer a sealed source outside its normal use area, HPS must be notified. An example, would be taking a source that is normally stored in the DTS building to the Medical Center building. In this instance, the researcher must first notify HPS, obtain written permission from licensed user, complete an entry on the appropriate sign-out sheet, and return the source to its storage area within three months.

8 Use of Ionizing Radiation Sources – Medical Applications

All Departments where sources of ionizing radiation are used on human subjects for diagnostic, therapeutic, or research purposes must develop Quality Assurance/Control Programs which will assure the safe and effective use of these sources. Written procedures must also be formulated. For research that involves human subjects, the Principal Investigator must be approved by the Institutional Review Board (IRB).

8.1 Requirements Pertaining To Unsealed Sources of Radioactive Materials

8.1.1 Isotope Dose Calibrator

Principal authorized users who are licensed to administer radiopharmaceuticals must possess and use a dose calibrator to measure the activity of dosages of photon-emitting radionuclides prior to administration to each patient. In addition, the following tests must be performed on the dose calibrator;

1. Instrument constancy test. This test must be performed at the beginning of each day of use.
2. Instrument accuracy test (energy linearity). This test must be performed upon the installation of the dose calibrator and at least annually thereafter.
3. Instrument activity linearity test. This test must be performed upon the installation of the dose calibrator and at least quarterly thereafter.
4. Geometric dependence test. This test must be performed upon the installation of the dose calibrator.

Moreover, these tests must also be performed following adjustment or repair of the dose calibrator. The importance of these tests is to assure that the patient would receive the prescribed dose.

The licensee shall mathematically correct dosage readings for any geometry or linearity error that exceeds 10 percent if the dosage is greater than 10 microcuries and shall repair or replace the dose calibrator if the accuracy or constancy error exceeds 10 percent.

The licensee shall retain a record of each check and test required by this section for a period of three years while for the geometric dependence test for the duration of the use of the dose calibrator. The records required must contain the information required by the US NRC, including:

- For the constancy test: the model and serial number of the dose calibrator, the identity of the radionuclide contained in the check source, the date of the check, the activity measured, and the initials of the individual who performed the check.
- For the accuracy test: the model and serial number of the dose calibrator, the model and serial number of each source used, the identity of the radionuclide contained in the source and its activity, the date of the test, the results of the test, and the identity of the individual performing the test.

- For the linearity test: the model and serial number of the dose calibrator, the calculated activities, the measured activities, the date of the test, and the identity of the individual performing the test.
- For the Geometry test: the model and serial number of the dose calibrator, the configuration of the source measured, the activity measured for each volume measured, the date of the test, and the identity of the individual performing the test.

8.1.2 Measurement of Dosages

Upon the use of unsealed sources of ionizing radiation on human subjects, a licensee shall:

1. Measure the activity of each dosage of the radionuclide.
2. Retain a record of the measurements for three years. The record must contain the information required by the US NRC, including:
 - a. Patient's name.
 - b. Name of the radiopharmaceutical.
 - c. Prescribed/recommended dosage and activity of the radionuclide at the time of measurement.
 - d. Date and time of measurement.
 - e. Initials of the individual who made the record.

For Iodine-131 dosages greater than 30 microcuries, the radiopharmaceutical may not be administered if the measured dosage differs from the prescribed dosage by more than 10 percent of the prescribed dosage and the difference between the administered dosage and prescribed dosage exceeds 15 microcuries. For therapeutic radiopharmaceutical dosage, other than I-131, the radiopharmaceutical may not be administered if the measured dosage differs from the prescribed dosage by more than 10 percent of the prescribed dosage. Contact Health Physics Services for further instruction.

The dose administered to the patient should be in accordance with what is needed for the treatment. Any extra dosage will increase the dose to the patient.

8.1.3 Permissible Molybdenum-99 Concentration

Principal authorized users who use molybdenum-99/technetium-99m generators for preparing a technetium-99m radiopharmaceutical shall measure the molybdenum-99 concentration in each eluate or extract, and retain a record of each measurement for three years. The record must contain the information required by the US NRC, including:

- The measured activity of the technetium expressed in millicuries.
- The measured activity of the molybdenum expressed in microcuries.
- The ratio of the measures expressed as microcuries of molybdenum per millicuries of technetium.
- The time and date of the measurement.
- The initials of the individual who made the measurement.

Licensees shall not administer radiopharmaceuticals that contain more than 0.15 microcurie of molybdenum-99 per millicurie of Tc-99m at the time of administration.

8.1.4 Radiation Safety Surveys

In addition to the requirements given in section 5.3.3, the licensee must perform the required radiation safety surveys as stipulated below. Record of each survey must be retained for three years. Survey forms may be obtained from the Health Physics Services.

All areas where radiopharmaceuticals are prepared or administered must be surveyed with an appropriate survey meter at the end of each day. Other areas such as imaging rooms, waste storage areas, patient waiting areas and corridors need to be monitored on weekly basis. Personnel should monitor their hands for contamination either after each procedure or before leaving the lab. Surveys for contamination must be performed with the count per minute scale. Any location that reads three times the background should be decontaminated. For more exact decontamination requirements, refer to section 5.3.3.

All departments where unsealed sources of ionizing radiation are used must possess an appropriate radiation detection survey instrument. This radiation survey instrument must be calibrated at least annually or as recommended by the manufacturer by the Health Physics Services or the manufacturer. The Health Physics Services of the Environmental Health, Safety & Risk Management calibrates most of the radiation detection instruments free of charge.

8.1.5 Quality Assurance of Instruments

8.1.5.1 Liquid Scintillation Counter

The Carbon-14 unquenched standard must be read on daily basis. Moreover, a Chi-square test that uses the Carbon-14 standard must be performed on a daily basis in order to assess the system stability, with the test results recorded on a monthly chart.

8.1.5.2 Gamma Counter

In addition to the manufacturer recommendation, the gamma counter should be checked for constancy with a reference source before each day of use. Moreover, a monthly Chi-square test must also be performed.

8.1.5.3 Uptake Probe

Before each day of use, the uptake probe must be checked as per the manufacturer recommendations.

8.1.6 Safe Use of Radiopharmaceuticals

In addition to the regulations that are provided in other parts of this handbook, the following rules must be followed.

Syringe shields must be used for routine preparation of multi-dose vials and administration of radiopharmaceuticals to patients, except in those circumstances in which their use is contraindicated (e.g., recessed veins, infants). In these exceptional cases, other protective methods such as remote delivery of the dose (e.g., through the use of a butterfly needles) should be used.

A whole body and a finger dosimeters must be worn during the elution of generators, during the preparation, assay, and injection of radiopharmaceuticals; and when holding patients during procedures.

Radioactive solutions must be confined in shielded containers that are clearly labeled. Radiopharmaceutical multidose diagnostic and therapeutic vials must be labeled with the isotope, the name of the compound, and the date and time of receiving or preparation. A log book must be used to record the preceding information and total prepared activity, specific activity as mCi/cc at a specified time, total volume prepared, total volume remaining, the measured activity of each patient dosage, and any other appropriate information. Syringes and unit dosages must be labeled with the radiopharmaceutical name or abbreviation, type of study, or the patient's name.

Any individual who administers a dosage of iodine-131 in liquid state with activity greater than 37 MBq (1 mCi) must have a thyroid bioassay performed by the Health Physics Services.

Should heating of the radiopharmaceuticals be required, perform this procedure behind an appropriate shield.

8.1.7 Specific Instructions to Personnel

8.1.7.1 Housekeeping Personnel

All housekeeping personnel should be aware of the locations of all restricted area in order to practice good radiation protection measures. The measures are:

1. Get user permission and instructions from Health Physics Services personnel before cleaning any spill in restricted area.
2. Do not clean counter tops, hoods, refrigerators or sinks in restricted areas unless specifically requested and instructed by the area supervisor or Health Physics Services personnel.
3. Do not remove bedclothes, dishes, trash or other items from rooms posted with radiation signs unless specifically instructed by a member of the Health Physics Services.

8.1.7.2 Security Personnel

All security personnel should be aware of the locations of all restricted areas and be able to recognize packages containing radioactive material in order to practice good radiation protection measures.

8.1.7.3 Maintenance Personnel

All maintenance personnel should be aware of the locations of all restricted areas so that they may practice good radiation protection measures. These measures are:

1. Obtain permission from the Health Physics Services before working in an area that is in or adjacent to a restricted area.
2. Be aware of hoods, sinks, refrigerators and storage areas used for radioactive materials or sources.

8.1.7.4 Clerical Personnel

All clerical personnel in the departments that use sources of ionizing radiation should be aware of the locations of restricted areas so that they may practice good radiation protection measures. Good practice includes:

1. Do not eat, drink, smoke or apply cosmetics in areas where unsealed sources of ionizing radiation are used.
2. Do not store food or drink in refrigerators where unsealed sources of ionizing radiation are stored.

8.1.8 Instructions to Patients

For some administrations of radioactive materials, the discharged patients must be given oral and written instructions, on how to maintain doses to other individuals as low as is reasonably achievable after the patients are released. If the patient is breast-feeding, additional instructions may be necessary. Licensees may use the following tables to determine the activity above which instructions must be given to patients.

Table 1: Activities Above Which Instructions Should be given When Authorizing Patient Release.	
Radionuclide	Activity above which Instructions Are Required in MBq (mCi)
P-32	*
Ga-67	1739 (47)
Sr-89	*
Tc-99m	5550 (150)
In-111	481 (13)
I-131	259 (7)
Sm-153	5180 (140)
Y-90	*
* Activity is not applicable because of the minimal exposures to members of the public resulting from activities normally administered for diagnostic or therapeutic purposes.	
US Nuclear Regulatory Commission – Regulatory Guide 8.39: Release of patients administered radioactive materials	

Table 2: Activities of Radiopharmaceuticals that Require Instructions When Administered to Patients Who Are Breast-Feeding.

Radiopharmaceutical	Activity above which Instructions Are Required in MBq (mCi)	Recommended Duration of Interruption of Breast-Feeding
Ga-67 Citrate	1.48 (0.04)	1 month for 148 MBq (4 mCi) 2 weeks for 48.1 MBq (1.3 mCi) 1 week for 7.4 MBq (0.2 mCi)
Tc-99m DTPA	1110 (30)	
Tc-99m MAA	48.1 (1.3)	12.6 hr for 148 MBq (4 mCi)
Tc-99m Pertechnetate	111 (3)	24 hr for 1110 MBq (30 mCi) 12 hr for 444 MBq (12 mCi)
Tc-99m DISIDA	1110 (30)	
Tc-99m Glucoheptonate	1110 (30)	
Tc-99m HAM	370 (10)	
Tc-99m MIBI	1110 (30)	
Tc-99m MDP	1110 (30)	
Tc-99m PYP	925 (25)	
Tc-99m Red Blood Cell In Vivo Labeling	370 (10)	6 hr for 740 MBq (20 mCi)
Tc-99m Red Blood Cell In Vitro Labeling	1110 (30)	
Tc-99m Sulphur Colloid	259 (7)	6 hr for 444 MBq (12 mCi)
Tc-99m White blood Cells	148 (4)	24 hr for 185 MBq (5 mCi) 12hr for 74 MBq (2 mCi)
I-125 OIH	2.96 (0.08)	
I-131 OIH	11.1 (0.3)	
I-131 NaI	0.0148 (0.0004)	Complete cessation (for this infant or child)
Tl-201 Chloride	37 (1)	2 weeks for 111 MBq (3 mCi)

If there is no recommendation in Column 3, the maximum activity normally administered is below the activities that require instructions on interruption or discontinuation of breast-feeding.

US Nuclear Regulatory Commission – Regulatory Guide 8.39: Release of patients administered radioactive materials

8.2 Requirements Pertaining to Radiation Producing Equipments

8.2.1 Acquisition and Disposal

All Radiation Producing Equipment must be registered with the Health Physics Services. It is the responsibility of the concerned department to notify the Health Physics Services upon the acquisition of any new equipment. Radiation safety survey on new units must be conducted prior to their use.

The concerned department must notify Health Physics Services of any equipment intended for disposal. The Health Physics Services will work to ensure safe disposal of units. Refer to the HPS standard operating procedures manual for more details about the “Purchasing and Decommissioning of Radiation Producing Equipment” procedure.

8.2.2 Safety Rules for Imaging Procedures Using Ionizing Radiation

8.2.2.1 Quality Assurance for Diagnostic Radiology Equipments

Quality assurance and radiation safety tests on Radiation Producing Equipment must be in accordance with the regulations/recommendations of the Nuclear Regulatory Commission (NRC), National Council on Radiation Protection and Measurement (NCRP), the International Commission on Radiological Protection (ICRP), American Association of Physicists in Medicine (AAPM), Institute of Physics and Engineering in Medicine (IPEM), and the American Food and Drug Administration (FDA), and the International Atomic Energy Agency (IAEA).

8.2.2.2 Safety instructions

General guidelines

1. Before undertaking an imaging procedure with ionizing radiation, the door of the imaging room shall be closed.
2. No patient shall wait or change in the imaging room while another patient is being imaged.
3. During imaging procedures all staff should stand in the protective cubicles / designated areas.
4. When immobilization of a patient is needed, mechanical support or restraining devices should be used. If anybody should stay in the imaging room during a procedure he/she shall wear protective apparel.
5. Imaging parameters, used to perform the procedure, shall be written down on the request form of the patient.
6. The LMP of all female patients within the reproductive age group (15-45 years) shall be documented on the request form.
7. The patient radiation dose indicated on the imaging equipment, whenever applicable, shall be documented.
8. In addition to the protective apron, the radiologist/cardiologist should also wear a thyroid shield, lead gloves and lead glasses in order to reduce exposure to the thyroid, extremities and eyes whenever needed.
9. Fluoroscopic doses should be minimized by reducing the fluoroscopic time used. The cumulative timer should serve as a reminder of the fluoroscopy time elapsed. The cumulative fluoroscopic exposure timer should be set prior to each fluoroscopic procedure and the total cumulative fluoroscopic time should be documented on the patient's request form.

Fixed radiographic and/or fluoroscopic equipment

1. Strict limitation of field size to the area necessary for the particular examination shall be routinely practiced.
2. If image receptors require support, mechanical supports must be used, if possible.

3. If the gonads of the patient lie within or near the primary beam, gonad shields MUST be used if possible.
4. Fluoroscopic imaging should only be used for procedures requiring dynamic imaging, as well as angiographic and interventional procedures.

Mobile radiographic and/or fluoroscopic equipment

1. The radiographer shall wear a protective apron and shall ensure that no one except the patient is in the path of the primary beam.
2. Any person who should be near the patient during an X-ray exposure shall wear a protective apron.
3. Any person who need not be near the patient during an X-ray exposure, shall remain at least 2 meters away from the patient.
4. Whenever possible, mechanical support should be used for holding the image receptor; if not possible, the person holding the image receptor shall wear a protective apron and should avoid the primary beam.
5. During mobile fluoroscopic procedures, the image detector shall be as close as possible to the patient.
6. Mobile equipment should be used only for examinations where it is impractical to transfer patients to the imaging department.
7. Patients in adjoining beds should be at least 2 meters away from the central ray of the primary beam. If the beds cannot be moved, adjacent patients shall be furnished with a 0.5-mm lead equivalent apron.
8. Prior to making the X-ray exposure, the technologist will announce his/her intention to do so. No exposure is to be made if any person, other than the patient is within a 2 meters radius of the X-ray beam and is not properly shielded.

8.2.3 Safety Rules in Therapeutic Radiation Producing Machines

8.2.3.1 Authorization

Only a physician who is authorized by the University Radiation Safety Committee may prescribe therapeutic use of radiation. The use of radiation producing/emitting equipment shall be performed in accordance with the manufacturer instructions.

8.2.3.2 License Amendments

In addition to the changes specified in the Principal Authorized User's license, a principal authorized user shall apply for and must receive a license amendment before:

1. Making any change in any treatment room shielding;
2. Making any change in the location of the Linac or HDR units within the treatment room;
3. Using the Linac or HDR units in a manner that could result in increased radiation levels in areas outside the corresponding treatment rooms;
4. Relocating the Linac or HDR unit;
5. Allowing an individual not listed on the licensee's license to perform the duties of the medical physicist.

8.2.3.3 Safety Postings

A Principal Authorized User shall post the following:

1. An appropriate *Caution, Very High Dose Radiation Area* sign at the Linac and HDR rooms' doors.
2. An appropriate *Caution, Radiation Area* sign at the entrance to controlled areas (example: entrance to Linac control console area or HDR control console area).
3. An emergency procedure form at the Linac and HDR rooms' consoles

8.2.3.4 Safety Precautions

The licensee shall control access to the Linac and HDR rooms by a door at each entrance by equipping these entrances with an electrical interlock system that will:

1. Prevent the operator from beaming ON or exposing the source in the room unless each treatment room entrance door is closed;
2. Turn off the beam or retract the source immediately and automatically when an entrance door is opened

In addition, the licensee shall

1. Equip each entrance to the radiation therapy room with a beam condition indicator light (Beam ON/OFF).
2. Check the functionality of these lights before each daily use of the Linac or HDR unit
3. Provide each treatment room with an audio/video patient monitoring system
4. Provide a functional radiation detector which will be used for HDR treatments to verify at the end of the treatment that the source has returned to the unit's safe (exit survey).
5. Check before each HDR treatment that the detector above is functional
6. Arrange for the prompt repair of any treatment related or QA related equipment that is not operating properly, and shall not use the Linac or HDR until the problem has been repaired and the equipment deemed safe to use by the physicist.
7. Measure the source strength for each newly installed HDR source to corroborate the manufacturer provided source strength, before medical use of the new source
8. Check all Linac relevant parameters (such as output, energy, flatness etc.) that may have been affected by a repair or other technical intervention. This check shall take place before treatments resume with the Linac.
9. Document compliance with all the above

8.2.3.5 Dosimetry Equipment and Quality Assurance

The licensee shall setup and follow a Quality Assurance program as described in the Radiation Oncology Department's Policies and Procedure Manual. This QA program is based on guidelines recommended by the American Association of Physicists in Medicine (AAPM) in TG-40 (Comprehensive QA for radiation oncology, 1994), TG-51 (protocol for clinical reference dosimetry of high-energy photon and electron beams, 1999), TG-41 (Remote Afterloading Technology, 1993), TG-56 (Code of practice of brachytherapy physics, 1997) and TG-59 (High dose rate brachytherapy treatment delivery, 1998). These guidelines suggest various daily, monthly and yearly quality control tests with corresponding record keeping.

8.2.3.6 Radiation Surveys for Radiation therapy Facilities

Before medical use, after each installation of a new linac or a new HDR unit (not source), and after making any change to the structural shielding, the licensee shall perform radiation surveys with a portable calibrated radiation measurement survey instrument to verify that dose rates outside the treatment rooms are in accordance with the exposure limits set in Chapter 11 of this handbook.

8.2.4 Shielding

8.2.4.1 Patient Shielding

Sensitive body organs (e.g., lens of eye, gonads) should be shielded whenever they are likely to be exposed to the useful beam provided that such shielding does not eliminate useful diagnostic information or proper treatment. Shielding should never be used as a substitute for beam collimation.

Gonads must be shielded with at least 0.5 mm of lead equivalence during diagnostic procedures in which gonads are within or closer than 5cm to the useful beam, except for cases in which this would interfere with the diagnostic procedure.

8.2.4.2 Personnel Shielding

Personnel who remain in the room during examinations must be protected by proper shielding.

1. All personnel in the room during an exposure should wear lead aprons.
2. Personnel who are likely to be exposed to high levels of scattered radiation to the thyroid during any procedure should wear thyroid shields.
3. Lead glasses can greatly reduce the exposure of eye lenses to scattered radiation in fluoroscopy, especially for physicians.
4. Any person who must have his or her hand near the primary beam (as in cases in which no other means is available to immobilize a patient) should wear lead gloves to reduce exposure of the extremities.

8.2.4.3 Structural Shielding

Each radiographic room shall be designed with sufficient shielding in the walls to provide protection to anyone outside of the room. Tampering with the integrity of the shielded walls is strictly prohibited. If any personnel notices structural changes, such as holes drilled into walls, Health Physics Services must be notified immediately.

In order to provide an evaluation, technical advice, or official approval on shielding requirements for a radiation installation, the following information shall be submitted to the Health Physics Services.

The plans shall show, as a minimum, the following:

1. The normal location of the x-ray system's radiation port; the port's travel and traverse limits; general direction(s) of the useful beam; locations of any windows and doors; the location of the operator's control panel.
2. The structural composition and thickness or lead equivalent of all walls, partitions, floor, and ceiling of the room(s) concerned.
3. The dimensions of the room(s) concerned and inter-floor distances if occupied.

4. The type of occupancy of all adjacent areas inclusive of space above and below the room(s) concerned. If there is an exterior wall, show distance to the closest area(s) where it is likely that individuals may be present.
5. The type of examination(s) or treatment(s) which will be performed with the equipment.
6. Information on the anticipated workload of the x-ray system(s).
7. Linac and brachytherapy treatment rooms shielding design shall be in agreement with NCRP 151 guidelines and shall result in doses to staff and public in accordance with dose limits specified in Chapter 11 of this handbook.

8.2.5 Pregnant Patient and Pregnant Worker Policy

8.2.5.1 Radiation and Pregnant Personnel

8.2.5.1.1 Diagnostic procedures and research

It is the employer's responsibility to provide a safe working environment for pregnant staff members. Once the pregnancy of a staff is confirmed, the Health Physics Services should be notified. Pregnant staff assumes all risk until she specifically declares her pregnancy in a written and signed statement to her supervisor and to the Health Physics Services. At that time, the University will be responsible for assuring that the duties of a female staff member will not result in a dose equivalent that is more than 5 mSv (0.5 rem) to the fetus.

Guidelines for protecting the embryo/fetus in a pregnant staff are:

1. Distance protection shall be practiced at all times.
2. Holding patients for immobilization shall be prohibited.
4. In addition to the monitoring device that is worn outside of the protective apron, an additional monitoring device shall be worn at waist level under the protective apron to determine exposure directly to the fetus.
5. Generator elution and kit preparation shall not be performed during the first trimester.
6. Therapeutic amounts of radionuclides shall not be administered by the pregnant staff.
7. Millicurie amounts of ^3H , ^{14}C , ^{125}I , or ^{131}I shall not be handled by the pregnant staff.
8. Extra care shall be observed to avoid spillage, vaporization, and internal/external contamination of the pregnant employee.

8.2.5.1.2 Radiotherapy

Due to the possible danger from radiation exposure to an unborn fetus, especially in the first three months of gestation, any radiation worker who becomes pregnant should declare that fact to their supervisors and to the Physicist/RSO at the earliest possible. This declaration is not mandatory but is strongly recommended in an effort to protect the fetus. Upon pregnancy declaration, the following steps should be applied to keep the employee's occupational dose less than 5mSv for the entire gestation period:

- a. Employee should contact her supervisor, the physicist and the RSO and declare her pregnancy
- b. Employee should make use of all protective measures and devices available, ie, lead clothing, lead lined barriers, minimizing time in presence of radiation, maximizing distance between them and the radiation source

- c. If employee is participating in a task where she isn't adequately protected, attempts will be made to reassign her to another task
- d. Employee shall not hold patients being imaged. Another employee should perform that task instead.
- e. during her pregnancy, employee should check with the physicist on a timely (monthly, preferred) basis to review her accumulated dose and to be updated on safe practical measures.
- f. Employee must comply with the above rules in order to assure their safety.

8.2.5.2 Radiation and Pregnant or Potentially Pregnant Patient

8.2.5.2.1 Diagnostic Radiology

1. Pregnant patient

- a. The referring physician requesting the procedure should consider if an alternative non ionizing imaging procedure would be of diagnostic value
- b. Prior to imaging a pregnant patient, the radiographer should obtain the approval of the radiologist. The radiologist may modify/postpone/reject/ the procedure after weighing the benefits/risks based on the required diagnostic information. The radiologist will inform the referring physician of his decision.
- c. The risks and benefits of the procedure should be explained to the patient and her consent be obtained if the examination is to be performed.
- d. The radiographer shall assure that the radiation dose delivered to the fetus is as low as reasonably achievable (ALARA)
- e. If the imaging procedure does not involve the abdominal area, then a lead apron should be placed on the patient's abdomen to protect the fetus from radiation.

2. Potentially Pregnant Patient

- a. The radiographer shall rule out pregnancy in all patients within the childbearing age by the application of the ten-day rule (Appendix M).
- b. The radiographer shall ask and document the date of the LMP for all patients within the childbearing age group.
- c. The radiographer shall apply the ten-day rule.
- d. The date of the radiographic examination to be performed should fall within the ten days from the 1st day of menstruation.
- e. If the date of the radiographic examination to be performed does not fall within the ten days from the 1st day of menstruation, the radiographer should ask the patient if there is any possibility of pregnancy.
- f. If the patient rules out the possibility of the pregnancy, the radiographer should document the response of the patient and the signature on the radiographic request form.
- g. If the patient cannot rule out the possibility of a pregnancy, the patient is assumed to be pregnant and the procedure in paragraph 8.4 shall be followed.

8.2.5.2.2 Radiotherapy

It is the responsibility of the radiation oncologist to screen patients in order to rule in or out the possibility of pregnancy.

In case of pregnancy, radiotherapy is usually contraindicated. In some cases however, when strong indications exist in favor of treatment, the physician and patient may choose together to go ahead with radiotherapy despite pregnancy.

In the event the patient was pregnant and she decided to undergo radiation therapy while pregnant

- a. Possible late radiation effects to the anticipated newborn will be explained to the patient and a written consent obtained from her for the treatment.
- b. Upon the radiation oncologist's request, fetal dose shall be assessed by the physicist using measurements in vivo or in phantom.
- c. Every possible measure shall be taken to minimize fetal dose (beam orientation, uterus shielding...)
- d. A physics report detailing the treatment setup, shielding and the corresponding fetal dose assessment shall be placed in the patient's chart.

In case the patient was initially declared not pregnant and later during or after the treatment course she was found to be pregnant, an incident report shall be filed and the patient would undergo proper counseling regarding the involved risks.

8.2.5.2.3 Nuclear Medicine and the Nursing Patient

The NM personnel should inquire about the possibility of breast-feeding, and the response shall be documented on the request form.

Following the nuclear medicine procedure, the nursing patient shall be advised by the nuclear medicine personnel about the interruption/suspension of breastfeeding as per Appendix I.

8.3 Radiopharmaceutical Therapy

Therapeutic use of iodine-131 must be performed in accordance with "Radiation Safety Policy Pertaining to Iodine Therapy" which assigns responsibilities to all the concerned departments/divisions.

8.3.1 Endocrinology and Health Physics Services Personnel

All personnel who are involved with iodine therapy must attend a radiation safety training session that is provided by the Health Physics Services (HPS) before they are allowed to participate in the iodine therapy procedure.

1. Patient cooperation is extremely important in minimizing unnecessary incidents and exposure to personnel, relatives, and other members of the general public. It is therefore essential that the patient is given a careful explanation by his/her physician as to the nature of the treatment and the safety measures involved.
2. It is the responsibility of the physician in charge to ensure that radiation safety guidelines are followed.
3. Before iodine is administered to a patient, the patient's doctor must provide verbal and written instruction (Instruction to Patients Receiving Iodine-131 pamphlet) to the patient. These instructions will help to reduce contamination and to keep radiation dose to household members and the public as low as reasonably achievable (ALARA).

4. Patient receiving iodine treatment shall be admitted in the dedicated room for iodine therapy.
5. All personnel involved in the administration or preparation of iodine must wear a film badge and a TLD ring.
6. All doses greater than or equal to 1110 MBq (30 mCi) must be administered in the patient's room. The vial containing the iodine capsule must be vented in a fume hood before being transported to the patient room. Endocrinology personnel must transfer the iodine capsule in a lead-shielded container to the patient's room. The most direct route with the least occupied areas should be used.
7. Prior to iodine administration, the activity of the iodine must be measured by the use of a dose calibrator. If the measured dose differs from the prescribed dose by more than 10 percent, contact the patient physician and HPS for further instruction. Records of these measurements must be maintained for a period of three years and must contain the following information:
 - a. Patient's name.
 - b. Name of radiopharmaceutical.
 - c. Prescribed dosage and activity of the dosage at the time of measurement.
 - d. Date and time of measurement.
 - e. Initials of the individual who made the record.
8. The administration of iodine capsule must be performed as follow:
 - a. Remove the lead container from the transport box and put it on the table close to the patient, then stand at least 2 meters away.
 - b. Have the patient remove the vial from the lead container and swallow the capsule.
 - c. After the intake of the capsule, the patient should drink a hot drink.
9. The door of the patient's room must be posted with a removable sign that consists of the radiation symbol and the following text in English and Arabic: "Caution Radioactive Materials", "No Visitors Allowed". Another sign to prohibit entry without impermeable shoe covers and gloves is to be posted on the door of the room.
10. For patients receiving 1110 MBq (30 mCi) or more, immediately after the administration of iodine, the dose rate must be measured by HPS personnel at 1 and 2 meters from the patient, and at the adjacent areas as specified in the Iodine Therapy Survey Form, with the results of the survey recorded in the form. The exposure level at one meter from the patient must also be measured daily with the result entered into the form, until the measured dose rate is less than 5 mR/h.
11. Radiation levels outside of the iodine patient room shall be maintained less than 2 mR/h in the corridor and less than 0.6 mR/h in adjacent occupied rooms.
12. Iodine patient shall not be discharged until the remaining activity of iodine in his body is less than 1110 MBq (30 mCi) of iodine-131 or the dose rate at one meter from the patient is less than 50 μ Sv/hr (5 mrem/hr).
13. After patient's discharge, the patient's room must be surveyed for contamination by HPS. Prior the release of the room for another iodine patient, removable contamination must be less than 2,000 dpm per 100 cm² and fix contamination less than 10,000 dpm per 100 cm².

14. The linen in the room shall be disposed of as radioactive waste and stored for decay in the radioactive waste room by the Housekeeping personnel under to direct supervision of the HPS staff.

8.3.2 Nursing Services Staff

8.3.2.1 Educational Requirements

All personnel caring for patients undergoing iodine therapy must attend on annual basis the radiation safety instructional session that is provided by Health Physics Services (HPS). These personnel shall be familiar with all of the information provided in this guideline. A copy of this guideline shall be kept at the nurse's station. Additional lectures may be provided by HPS upon request.

8.3.2.2 Instructions

Radioactive iodine will appear in the urine, saliva, perspiration, tears, and other body fluids, so without compromising patient care, the following instructions must be strictly adhered to:

1. Personnel are encouraged to consult HPS for any questions that pertain to radiation safety.
2. Nurses should review the "Radiation Safety Policy Pertaining to Iodine Therapy" before radioactive iodine is administered to the patient.
3. The patient must be admitted to the iodine therapy room and confined to his/her room except for special medical or nursing purposes approved by his/her doctor *and* HPS.
4. Visitors are not allowed.
5. All personnel caring for patients undergoing iodine therapy must be monitored for radiation exposure.
6. Pregnant personnel shall not enter the patient room.
7. All personnel entering the room must wear impermeable gloves and shoe covers. Disposable gloves and shoe covers must be positioned outside the patient room and a designated waste container is to be positioned inside the room, next to the door. The gloves and shoe covers must be removed and disposed of in the designated waste container before leaving the room. Shoe covers should be removed first while still wearing the gloves. After removing the gloves and leaving the room, hands must be washed.
8. Disposable items must be used in the care of iodine patients. Left over food and eating utensils must be placed in a closed plastic bag. No item is to be removed from the patient's room before the approval of HPS.
9. The patient should be encouraged to drink lots of fluids for hydration and to flush the toilet 3 times after each use. Patients should also be instructed to wash their hands in plenty of warm, soapy water after each use of the toilet. Male patients must be instructed to sit down when urinating in order to avoid splashing.
10. For routine nursing care, only the minimum required time should be spent near the patient. The distance between personnel and the patient should be maximized but to a point where it still allows the appropriate care to be given. Lead shields should be used whenever it is needed.
11. If a nurse, attendant, or anyone else knows or suspects that his/her skin or clothing, including shoes, is contaminated, HPS should be notified immediately. This person should remain in an area adjacent to the patient's room and should not walk around in the hospital. If hands become contaminated, they must be washed immediately.
12. If urine from a patient is to be collected, HPS should be contacted first. The patient should collect his/her own urine. If the patient is bedridden, a separate urinal or bedpan should be provided. The nursing services staff shall apply ALARA when caring for bedridden patients. The

urinal or bedpan must be flushed several times with hot soapy water after each use. Utmost precautions must be taken to see that no urine or vomit is spilled on the floor or bed.

13. Surgical dressings should be changed only as directed by the physician and in the presence of HPS. These dressings must remain in the room until they are monitored by a radiation survey meter for contamination. These dressings should be handled only with tongs or tweezers.
14. Bed baths shall not be given to the patient.
15. Housekeeping must not enter the room unless under the direct supervision of the HPS.

8.3.2.3 Misadministration

Misadministration means the administration of:

1. A radiopharmaceutical dosage greater than 30 microcuries of either sodium iodide I-131:
 - A. Involving the wrong individual or wrong radiopharmaceutical, or
 - B. When both the administered dosage differs from the prescribed dosage by more than 20 percent of the prescribed dosage and the difference between the administered dosage and prescribed dosage exceeds 30 microcuries.
2. A therapeutic radiopharmaceutical dosage, other than sodium iodide I-125 or I-131:
 - A. Involving the wrong individual, wrong radiopharmaceutical, or wrong route of administration; or
 - B. When the administered dosage differs from the prescribed dosage by more than 20 percent of the prescribed dosage.
3. A radiation therapy radiation dose:
 - A. Involving the wrong individual, wrong mode of treatment, or wrong treatment site;
 - B. When the treatment consists of three or fewer fractions and the calculated total administered dose differs from the total prescribed dose by more than 10 percent of the total prescribed dose;
 - C. When the calculated weekly administered dose is 30 percent greater than the weekly prescribed dose; or
 - D. When the calculated total administered dose differs from the total prescribed dose by more than 20 percent of the total prescribed dose.
4. A diagnostic radiopharmaceutical dosage, other than quantities greater than 30 microcuries of sodium iodide I-131, both:
 - A. Involving the wrong individual, wrong radiopharmaceutical, wrong route of administration, or when the administered dosage differs from the prescribed dosage; and
 - B. When the dose to the individual exceeds 5 rems effective dose equivalent or 50 rems dose equivalent to any individual organ.

All misadministrations must be immediately reported to the Health Physics Services.

8.3.2.4 Emergencies

Medical Emergencies

Notify immediately the attending physician and the Health Physics Services (HPS) if the patient has any medical emergencies. Life-saving procedures should be initiated immediately without concern for radiation exposure while attempting to take precautions against the spread of contamination. Direct contact with the patient's mouth should be avoided and all members of the emergency team

must wear impermeable protective gloves. Body fluids collected from the patient must be labeled "Radioactive" and the receiving laboratory must be notified. For emergencies that are not immediately life threatening, the advice of HPS must be sought on methods of reducing radiation exposures.

Aggravated/Uncooperative Patient

Contact the patient's attending physician and HPS if patient's behavior results in having the nursing staff repeatedly attend and calm the patient or to keep him/her from leaving the room, resulting in unnecessary exposure to personnel and the general public.

Spillage of Body Fluids

Spillage of an iodine patient body fluid (vomitus, incontinence, excessive sweating) will result in contamination of the area. If such contamination occurs while attending to the patient, the following steps must be followed.

- a. Keep calm and cover the spill with absorbent pads to contain the body fluid.
- b. For all personnel in the room, go to the door and take off your shoe cover. Close the door after leaving the room and remain by the door.
- c. Call the nursing station for assistance. If no one can hear, one person only should walk no further than is necessary to find someone to call HPS.
- d. Remove immediately any contaminated clothing and place it in a large plastic bag.
- e. Wash any contaminated skin with a mild soap and plenty of water; do not use a hard brush, or abrasive soap.
- f. Wait for the arrival of HPS personnel.

8.4 Irradiation of Blood

The irradiation of blood components must be performed in accordance with the 'Quality Assurance' program and 'Standard Operating Procedure For Irradiation of Blood Components' as provided in Appendix J.

9 Use of Ionizing Radiation Sources – Non-Medical Applications

All Radiation Producing Equipments must be licensed by the University Radiation Safety Committee. Periodic safety inspections must be conducted. See Chapter 4 for licensing procedures. Radiation Producing Equipment used for research purposes and which will result in the exposure of human subjects to ionizing radiation must be checked as per the manufacturer recommendation and other relevant standards such as NCRP, FDA ...

9.1 X-Ray Diffraction or Fluorescence Machines

Radiation exposures from X-Ray diffraction or fluorescence machines can be extremely hazardous. Dose rates in the primary beam can exceed 100,000 R/minute. Any part of the body momentarily placed in the beam would receive enough radiation to cause serious radiation burns. X-Ray diffraction machines must be operated in accordance with the following regulations.

9.1.1 Operators of X-Ray Equipments

No individual will be permitted to operate an X-Ray diffraction or fluorescence machine until such person has received an acceptable amount of training in radiation safety, demonstrated competence to use the machine and radiation survey instruments which will be employed, and received the approval of the person licensed to possess and use the machine.

The operator of the X-Ray machine will be responsible for all operations associated with that equipment, including radiation safety. In particular, he or she will keep radiation exposures as low as practical, practice safety precautions and procedures as they apply to each machine operated, and notify Health Physics Services of known or suspected abnormal radiation exposures.

9.1.2 Operating Procedures

Operating procedures must be in writing and readily available to the operator. The operator should be in immediate attendance at all times when the machine is in operation. When not in operation, the machine must be secured in such a way as to be inoperable to unauthorized persons.

Only properly trained personnel are permitted to install, repair, or make other than routine modifications to the X-Ray generating apparatus and tube housing.

Radiation exposures to individuals must be so controlled that the maximum permissible dose limits specified in Section 11.1 are not exceeded. In particular, personnel must not expose any part of their bodies to the primary beam.

Procedures and apparatus utilized in beam alignment should be designed to minimize radiation exposure to the operator. Particular attention should be given to viewing devices to assure that lenses and other transparent components attenuate the radiation beam to minimal levels. When alignment involves working near the open primary X-Ray beam, the beam current should be reduced in order to lower exposure rates. If a fluorescent alignment tool is used, dimming the room light will permit a significant reduction in beam current. The fluorescent alignment tool should be long enough to permit the operator's hand to be kept at a safe distance from the beam. The operator should be familiar with the

manufacturer's recommended alignment procedures, and copies of these should be available for reference.

If, for any reason, it is necessary to alter safety devices, such as bypassing interlocks or removing shielding, such actions must be authorized in advance by the University radiation Safety Officer, must be performed under the supervision of the licensed user, and must be terminated as soon as possible and safety devices reinstalled. Any attempt to bypass or alter safety devices should only be undertaken as the very last opportunity to proceed with the research. During the bypass period, a readily discernible sign bearing the words "Safety Device Not Working" shall be placed on the radiation source housing.

9.1.3 Personnel Monitoring

An operator of X-Ray diffraction machines must wear a personnel monitoring device (a film badge or TLD monitor or finger ring) whenever he or she is operating or is near an operating machine, and if he/she meets the requirements of section 12.3. The film badge or TLD monitor should be worn on the torso and the finger ring should be worn on the hand most likely to be exposed.

9.1.4 Area Monitoring

Users must monitor regularly as per NCRP for stray or scattered radiation in the immediate vicinity of the X-Ray machine with an appropriate detector. Leakage radiation from the generator cabinet must be less than 0.25mR/hr at 5 cm. All safety devices (interlocks, shields, shutters, cabinets, etc.) must also be checked. In addition to routine surveys, a survey must be made after each repair or modification of the apparatus. If any modification is made to the machine, Health Physics Services must be notified. Radiation levels and results of safety device checks must be recorded in the Radiation Survey Log.

Radiation protection surveys will also be conducted by Health Physics Services staff biannually or upon request. Surveys by Health Physics Services are supplemental to the required surveys performed by the users. Refer to section 12.9 for more details.

9.1.5 High Voltage Hazards

The high voltage power supply of X-Ray machines can be particularly hazardous. Personnel must never tamper with high voltage equipment. Only properly trained personnel are permitted to install, repair, or modify high voltage equipment.

9.1.6 Safety Engineering

The equipment should incorporate safety engineering features of a fail-safe design to prevent possible exposures. For open beam configurations, a safety device to prevent entry of hands and other body parts into the primary beam, path is entered, must be provided. Unused ports must be secured so that the shutters cannot be opened unless a collimator or coupling is connected. Safety interlocks should be employed on tube head ports or shielding. The coupling between the X-Ray and the collimator of the diffractometer, camera, or other accessory must prevent stray X-Rays from escaping the coupling. Visual warning must be used to indicate the potential for radiation exposure on all devices of open beam configuration. Easily visible flashing lights or equally conspicuous signals located near the tube housing that indicate when the X-Ray tube is on or off must be provided if the primary beam is controlled in this manner. If the beam is controlled by shutters, a readily

discernible indication of shutter status (open or closed) must be located near each port on the radiation source housing. The warning devices should be of a fail-safe design and must be labeled so that their purpose is easily identified. A red warning light with the notation "X-RAY ON" or the equivalent, should be located on the control panel, and should light only when the X-Ray tube is activated.

A sign or label bearing the words "CAUTION – RADIATION, THIS EQUIPMENT PRODUCES X-RADIATION WHEN ENERGIZED" or words having similar intent, must be placed near any switch which energizes an X-Ray tube. A label bearing the radiation symbol and the words "CAUTION – HIGH INTENSITY X-RAY BEAM" must be placed on or adjacent to each X-Ray tube housing. It should be located so as to be clearly visible to any person who may be working near the primary radiation beam. Each area or room containing analytical X-Ray equipment must be posted with a sign bearing the radiation symbol and the words "CAUTION – X-RAY EQUIPMENT".

All safety devices (interlocks, shields, shutters, warning lights, etc.) must be tested by the user periodically to ensure their proper operation. Records of such tests must be written in the Radiation Survey Log.

9.2 Other X-Ray Machines

The regulations for analytical X-Ray machines apply in general to all other X-Ray machines used for non-medical purposes. Contact Health Physics Services for further information.

9.3 Other Radiation Machines

Requirements and Safety precautions for machines producing or using radiation other than x-rays must be considered on a case by case basis. Contact Health Physics Services at x2360 for further information.

10 Emergency Procedures

In the event of an emergency involving ionizing radiation, the Health Physics Services (2360) must be notified immediately. If the emergency is life threatening (serious injuries, fire, explosions, gas leak, etc.) the Protection Office must be notified immediately at any time by dialing 2400. The Protection Office will then call other emergency services (Emergency Response Team (ERT), Fire Department, ambulance, etc.) as needed. After hours, the Health Physics staff may be contacted through the Protection Office by dialing 2400.

10.1 Contamination of the Laboratory

In the event of a spill or accidental release of radioactive materials, immediately notify all other personnel in the room or immediate area of the spill, and the location of the spill. All personnel not involved in the spill must vacate the area, but should not walk through the spill while leaving and secure the area. If the release is gaseous or airborne radioactive material, hold your breath, vacate the room, and secure the door immediately. NOTIFY HEALTH PHYSICS SERVICES IMMEDIATELY.

Contaminated skin should be washed thoroughly with soap and water. Refer to Section 10.2 for procedures. Emergency showers should be used if necessary. For spills on your clothing, carefully remove outer protective clothing at once and place in a plastic bag.

Notify Health Physics Services as soon as possible so that Health Physics Services staff may supervise decontamination of the area. Be prepared to provide the University radiation safety officer with the following information:

- a) Your name and the name of the person in charge of the laboratory;
- b) The location of the laboratory and the location of the spill within the laboratory;
- c) The radionuclide and the estimated activity involved in the spill, the volume of liquid involved, and the chemical form of the labeled compound.

Each room where unsealed sources of radioactive materials are used must be posted with an written emergency procedure in Arabic and English for all workers to be able to consult in case of an emergency.

If the spill or release is not gaseous or airborne radioactive material and is chemically stable, wear protective gloves and control the spread of contamination.

For liquid spills:

- Set the container straight and stop the spread of liquid by placing disposable absorbent materials around the perimeter.
- Drop absorbent paper on the contained spill to absorb it.
- DO NOT WIPE FROM SIDE TO SIDE. You may spread the contamination and increase the hazard.
- Once the spill is absorbed, place the contaminated absorbent in the dry radioactive waste.
- If the absorbent is sopping wet, it must be dried on a tray in a fume hood before disposal.
- Clean the area by misting with detergent solution and then blotting with paper towels to remove, not spread, the contamination.
- When cleaning the area, work from the perimeter of the contamination zone towards the center.

- Monitor with wipe smears for removable contamination and with a survey meter for fixed contamination.
- Repeat the cleaning cycle until the area meets the contamination limits in section 5.4.3.
- Be very careful not to walk in a contaminated area. Contamination is easily spread by foot, which makes decontamination much more difficult.

Unless otherwise specified by the HPS staff, the procedure above shall be carried out by the user.

10.2 Contamination of the Staff

- Notify the Health Physics Services immediately.
- Thorough, gentle washing with soap and water is the best general method for decontamination of the hands and other parts of the body. It is most important not to harm the integrity of the skin and make the problem worse.
- If the exact nature of the contamination is known, it may be more effective to immerse the hands in a suitable reagent as soon as possible after contamination. This should be followed by a thorough washing with a mild soap and warm water. Wash gently and be careful not to harm the integrity of the skin.
- Detergents and wetting agents may also be useful; however, the skin may become sensitive following repeated applications of detergents to the same area. In all cases, avoid the use of organic solvents that may increase the probability of the radioactive materials being absorbed through the skin.

10.3 Contaminated Wounds

- When the skin is lacerated by broken glassware or other sharp objects contaminated with radioactive materials, immediately wash the wound area thoroughly with large volumes of cold water.
- If bleeding is not too severe, allow bleeding to further cleanse the wound.
- Notify Health Physics Services immediately and administer first-aid.
- Students and staff may contact the Emergency Room at the Medical Center.

10.4 Ingestion of Radioactive Materials

Accidental ingestion or swallowing of radioactive materials should be treated by a physician. Notify Health Physics Services immediately. Students and staff may contact the Emergency Room at the Medical Center.

10.5 Inhalation of Radioactive Materials

Accidental inhalation of gaseous or particulate radioactive materials should be treated by intentional coughing. Deep breathing of clean, non-radioactive air may also enhance the normal elimination process. Notify Health Physics Services immediately. Students and staff may contact the Emergency Room at the Medical Center.

10.6 High Radiation Exposure and Treatment

In the event of an accident involving exposure to a high dose of radiation sufficient to produce radiation sickness symptoms, notify Health Physics Services immediately.

11 Radiation Exposure

Permissible radiation exposures should be interpreted assuming that any radiation exposure, except for medical purposes, is undesirable. There is a certain amount of natural background radiation present in our environment which is unavoidable. The philosophy of radiation safety based on present knowledge and assumptions is to reduce all radiation exposure levels above background to a level "As Low As Reasonably Achievable" (ALARA). The maximum permissible exposures given below are to be used only as general guides. It should not be considered that these are tolerable exposures, but rather represent the upper limits which should be reached only infrequently, if ever.

11.1 Radiation Exposure Limits

The limits for maximum permissible external & internal radiation exposures are:

Area Affected	Annual Dose (mSievert)	Annual Dose (rem)
Total Effective Dose Equivalent	20 mSv averaged over 5 years not to exceed 50 mSv in any single year	2 rem per year averaged over 5 years not to exceed 5 rem in any single year.
Eye Dose Equivalent	150	15
Shallow Dose Equivalent (Skin or any extremity)	500	50
Individual Organ or Tissue	500	50
Dose to an embryo/fetus (during the pregnancy)	5	0.5

Internal and external exposure will be summed together to determine the Total Effective Dose Equivalent. Any person likely to receive greater than 10% of the above limits should be monitored for exposure. For the more restrictive dose limitations to an embryo/fetus to be in effect, the pregnant woman must voluntarily inform Health Physics Services in writing, of her pregnancy and the estimated date of conception.

The permissible limits for persons under 18 years of age are 10% of the above limits. The total effective dose equivalent to individual members of the public, from operations at the University, must not exceed 1 mSv (0.1 rem) per year.

For comparison with occupational limits, the radiation exposure from natural background is approximately 120 mR per year in Beirut. There are three primary sources for this natural exposure:

- Cosmic radiation from space which varies depending on the thickness of the atmosphere providing shielding; at Beirut is about 30 mR per year.
- External terrestrial radiation arises from traces of natural uranium and thorium found in rock and soils worldwide, and around Beirut it contributes about 60 to 70 mR/yr.
- Internally deposited radionuclides such as ^{40}K , a naturally occurring isotope of potassium, contributes about 20 mR/yr.

11.2 Internal Contamination

Internal contamination occurs as a result of radioactive materials ingested, inhaled, absorbed through the skin or wounds into the human body. No individual may intentionally be exposed to concentrations of radioactive contaminants in air or water in excess of the limits specified by the University Radiation Safety Committee or limits equivalent to those specified by the U.S. Nuclear Regulatory Commission.

1. **Ingestion:** Ingestion of radioisotopes may be prevented by not eating or drinking in areas where unsealed sources of radioactive materials are used. Pipetting by mouth suction is prohibited.
2. **Inhalation:** Should the radioactive material used be gaseous or airborne, a fume hood, or a glove box or an appropriate respiratory protection device shall used.
3. **Absorption:** Absorption through the skin or through cuts or abrasions may be prevented by wearing protective gloves, and by immediately washing the skin whenever contamination is suspected. Frequent changing of protective gloves is recommended.

12 Health Physics Services

In addition to the implementation of the radiation protection program, the Health Physics Services division of EHSRM, headed by the University Radiation Safety Officer, provide a number of services to faculty, staff and students in an effort to maximize the usefulness of radioactive materials in research and instructional programs and in clinical use.

12.1 Procurement of Radioactive Materials

Health Physics Services is available to assist licensed users in procurement of radioactive materials as described in Section 5.1. All receivings of radioactive materials, must take place through Health Physics Services.

Prior to delivery, each RAM package is examined for any possible contamination, logged into the Health Physics Services inventory system, and then delivered to the appropriate laboratory. The concerned department/division will be notified if the contamination was in excess of 1,000 dpm per 100 cm². Any package that is contaminated in excess of 10,000 dpm per 100 cm² will not be delivered to the department/division.

12.2 Transfers of Radioactive Materials

Health Physics Services is responsible for all transfers of radioactive materials to and from the University, and to and from any department/division of the University as described in section 5.1. Excluding certain packages that are specified by the Health Physics Services, all incoming shipments of radioactive materials shall be received at the Health Physics Services Laboratory, leak tested, and delivered to the purchasing department. Anyone who needs to transfer radioactive materials from one building to another must notify Health Physics Services.

12.3 Personnel Monitoring

12.3.1 Film Badge, TLD Monitors or Finger Rings Service

Film badges (worn for whole body exposure) and/or TLD or rings monitors are issued to all personnel using radioisotopes or radiation producing equipments, except those who work only with ³H, ¹⁴C, or ³⁵S as the dosimeters are not sensitive to the low energy beta emissions from these isotopes. Films or TLD monitors are changed on a monthly basis. Health Physics Services personnel delivers new dosimeters to each department. Each department must have one person who is responsible for the distribution and collection of dosimeters. All personnel that are issued dosimeters must wear their dosimeter during working hours. Health Physics Services sends dose summary reports to the head of each department on a monthly and annual basis. Dosimeters should not be taken home where they may be lost or misplaced. Any person expected to receive greater than 10% of the annual limits described in section 11.1 should be provided with a dosimeter. Complete radiation exposure records are available upon request.

Health Physics Services are required to maintain a permanent record of all occupational exposures to radiation. This includes obtaining an exposure history from all previous work places. In addition, Health Physics Services must annually notify each employee of his or her exposure.

12.3.2 Urine Bioassay Service

Personnel working with tritium (^3H) will be regularly requested to submit urine samples for analysis of potential internal contamination. Urine samples are collected for analysis for internal ^3H contamination using the following guides:

Amount of ^3H Activity Routinely Used in Single Operations	Urine Sample Frequency
Less than 370 MBq (10 mCi)	Not Required
Greater than 370 MBq (10 mCi)	Once per Month
Greater than 3700 MBq (100 mCi)*	Once per Week

If urine or other bioassays are required for other radioactive materials, they will be written as a condition of the individual license as the need arises. Bioassay services for lower working levels, or for special experimental procedures, will be provided upon request.

12.3.3 Thyroid Counts

Personnel working with a liquid form of ^{125}I solutions in excess of 37 MBq (1 mCi) must call Health Physics Services after each such experiment and make an appointment for a thyroid count. Before the research project with radioiodine begins, a baseline or background count of the thyroid should be obtained by the Health Physics Services. Special equipment is available to detect thyroid uptakes as low as 1 nanocurie. Persons working with smaller amounts of ^{125}I solutions should also be counted if internal contamination is suspected or possible.

12.4 Contamination Surveys and Wipe Tests

In addition to the required contamination surveys performed by the user, routine surveys for radioactive contamination will also be conducted by Health Physics Services. The frequency of the surveys is typically once per month, depending on the nature of the procedure. A report of higher-than-background contamination levels will be sent to the lab supervisor. Contamination is reported as disintegrations per minute per 100 square centimeters of area wiped. Decontamination requirements are given in the following guide:

Level of Contamination	Action Required
Less than 100 dpm/100 cm ²	No action required
Between 100 & 1,000 dpm/100 cm ²	Clean-up of area recommended
Greater than 1,000 dpm/100 cm ²	Clean-up of area, resurvey

It is impossible for Health Physics Services to follow-up each experiment with a survey. Therefore, users of radioactive materials are required to conduct and record surveys on their own. Refer to Section 5.3 for further information.

12.5 Freezer Surveys

Routine surveys for ^3H contamination of freezers are also conducted by Health Physics Services. These surveys are performed on a semiannual basis. Contamination is reported as disintegrations per minute per milliliter of frost melt or per wipe smear for frost-free refrigerators. Refer to Appendix D for more details about the “Tritium Decontamination of Freezers” procedure.

12.6 Decontaminations

Health Physics Services is required to supervise decontamination of laboratories, equipment, and personnel. Refer to Chapter 10 for instructions to be followed in the case of contamination. **DO NOT ATTEMPT DECONTAMINATION WITHOUT THE APPROVAL OF HEALTH PHYSICS SERVICES.** Some contamination problems require special procedures and equipment.

12.7 Leak Tests of Sealed Sources

Except for the sealed sources used in the Radiation Oncology Department, the Health Physics Services will perform all required sealed source leak tests. Persons responsible for the sealed sources will be informed of test results. Sealed sources in the Radiation Oncology Department shall be tested by the Medical Physicist of the Radiation Oncology department as required by NRC/Manufacturer. These tests shall be supervised by the Health Physics Services as and when needed.

12.8 Survey Instrument Calibration

Health Physics Services will perform survey instrument calibrations annually, with the exception of those requiring unusual calibration by the manufacturer. All new ionizing radiation detectors acquired by various departments/divisions, must be registered with the Health Physics Services.

12.9 Radiation Producing Equipments Surveys, Non-Medical Application

X-ray equipments are routinely as per corresponding requirements surveyed for scattered radiation and checked for proper operation. A report of the survey is sent to the licensed user. The user must notify Health Physics Services of any major modifications, so that a resurvey can be performed. As discussed in section 9.1.4 the user is also required to conduct routine radiation surveys of their equipment.

12.10 Radioactive Waste Disposal

Radioactive waste will be routinely removed from the laboratories and transferred to the Health Physics Services laboratory for disposal. Health Physics Services provide properly labeled containers for solid radioactive waste, lined with plastic bags. Labeled polyethylene bottles, in 1 and 6 gallon sizes, are provided for liquid radioactive waste. The 6 gallon bottles are supplied in a yellow metal can, which serves as a secondary container. Other radioactive waste containers can be provided upon request. To obtain waste containers, or to request the disposal of radioactive waste, call Health Physics Services on extension 2360. Refer to section 5.5 for additional information.

12.11 Radioactive Materials Inventory

Health Physics Services takes a quarterly inventory of all radioactive materials possessed by the University. The inventory is printed and distributed to all licensed users. The purpose of the inventory is to check laboratory possessions against individual license limits. It also serves the user by providing a list of materials available for use and their locations.

Users of radioactive materials are required to record on the inventory provided to them the extent to which their stock of materials has been consumed. Inter-laboratory transfers of radioactive materials must be authorized in advance by Health Physics Services, and then recorded on the inventory when the actual transfer occurs. The inventory will be updated on a quarterly schedule and reprinted for the convenience of the user.

12.12 Radiation Safety Education and Training

The Health Physics Services will provide education and training to all AUB staff working with ionizing radiation. Several sessions will be conducted annually and will concentrate on the nature of ionizing radiation work of the attendees.

The head of the department/division shall ensure that all the staff who fall under his jurisdiction are certified by HPS to work with ionizing radiation, and are attending the yearly refresher sessions.

The head of the department/division shall inform HPS about any new staff member who will start working with ionizing radiation, so that a training session for him/her will be scheduled.

12.13 Radiation Safety Inspections

HPS staff will inspect each department/division where sources of ionizing radiation are used for compliance with the University Radiation Safety Regulations on a monthly basis.

A compliance checklist will be filled and non-compliances reported to the principal authorized user and to the chairperson of the University Radiation Safety Committee. A follow up visit will then be scheduled.

If during the follow up visit the same non-compliance was observed, the department head will be notified and the chairperson of the University Radiation Safety Committee will advise the principal authorized user of sanctions that may include suspension of ionizing radiation sources purchasing privileges, or outright suspension of the license, based on the URSC decision.

Appendices

- A. Glossary of Radiation Units and Terms**
- B. Summary of Radiation Health Risks**
- C. Required List of Supplies to be Present in the Laboratory**
- D. Tritium Contamination of Freezers**
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- I. Radiation Safety Policy Pertaining to Iodine Therapy**
- J. Irradiation of Blood Component: Quality Assurance & Standard Operating Procedure**
- K. Radioactive Material Receipt Procedures**
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- M. The Ten-Day Rule for Potentially Pregnant Patients**

Appendix A

Glossary of Radiation units and Terms

Absorbed Dose: The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The units of absorbed dose are the “Gray” (one Gray (Gy) equals one joule per kilogram) and the “rad” (one rad equals 100 ergs per gram). The Gray in the new SI unit while the rad is the old conventional unit. $1 \text{ Gy} = 100 \text{ rad}$.

Absorption: The process by which radiation imparts some or all of its energy to any material through which it passes. Self-absorption occurs when the emitting material absorbs some or all of its own radiation.

Activity: The number of nuclear transformations occurring in a given quantity of material per unit time. (See Becquerel or Curie)

Alpha Particle: A charged particle (two protons and two neutrons) emitted from the nucleus of an atom.

Area Monitoring: Routine monitoring of the radiation level or contamination of a particular area, building, room, or equipment.

Artificial Radioactivity: Man-made radioactivity produced by particle bombardment or electromagnetic radiation, as opposed to natural radioactivity.

Attenuation: The process by which a beam of radiation is reduced in intensity when passing through some material. It is the combination of absorption and scattering processes and leads to a decrease in flux density of the beam when projected through matter.

Background Radiation: Radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present. There may also be background radiation due to the presence of radioactive substances in other parts of the building, in the building material itself, etc. See Natural Radioactivity.

Becquerel (Bq): A unit, in the International System of Units (SI), of measurement of radioactivity equal to one transformation per second.

Beta Particle: Charged particle emitted from the nucleus of an atom with a mass and charge equal to that of the electron.

Bioassay: The collection and analysis of human hair, tissue, nasal smears, urine or fecal samples to determine the amount of radioactive material that might have been ingested by the body.

Bremsstrahlung: Secondary photon radiation produced by deceleration of charged particles passing through matter.

Calibration: The check or correction of the accuracy of a measuring instrument to assure proper operational characteristics.

Contamination, Radioactive: Deposition of radioactive material in any place where it is not desired,.

Controlled Area: A defined area in which the occupational exposure of personnel to radiation is under the supervision of the Radiation Protection Supervisor. Also called a restricted area.

Cosmic Rays: High energy particulate and electromagnetic radiations which originate outside the earth's atmosphere.

Count (Radiation Measurements): The external indication of a device designed to enumerate ionizing events. It may refer to a single detected event or to the total number registered in a given period of time. The term is often erroneously used to designate a disintegration, ionizing event, or voltage pulse.

Curie (Ci): A unit of activity. One curie equals 3.7×10^{10} nuclear transformations per second.

Daughter: Synonym for decay product.

Decay, Radioactive: Disintegration of the nucleus of an unstable nuclide by spontaneous emission of charged particles and/or photons.

Decay Product: A nuclide resulting from the radioactive disintegration of a radionuclide formed either directly or as the result of successive transformations in a radioactive series. A decay product may be either radioactive or stable.

Decontamination: The removal of contaminating radioactive material from a structure, area, object, or person.

Detector, Radiation: A material or device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis.

Disintegration, Nuclear: A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus. When large numbers of nuclei are involved, the process is characterized by a definite half-life.

Dose: A general term denoting the quantity of radiation or energy absorbed.

Dose Equivalent: A quantity used in radiation protection. It expresses all types of radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose and the quality factor. The units of dose equivalent are the Sievert (Sv) and the rem ($1 \text{ Sv} = 100 \text{ rem}$). The Sv is the new SI unit while the rem is the conventional unit.

Dose Rate: Absorbed dose delivered per unit time.

Dosimeter: Instrument to detect and measure accumulated radiation exposure. Film badges, TLD finger rings, and pocket ionization chambers are commonly used dosimeters.

Electron: An elementary particle with a unit negative charge and a mass 1/1837 that of the proton. Electrons surround the positively charged nucleus and determine the chemical properties of the atom.

Exposure: A measure of the ionization in air by x or gamma radiation. It is the sum of the electrical charges on all ions of one sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. One roentgen (R) = 2.58×10^{04} coulombs per kilogram. In reference to biological exposures, Acute Exposure is that received in a short period of time and Chronic Exposure is that received over a long period of time.

External Radiation: Radiation from a source outside the body – the radiation must penetrate the skin.

Film Badge: A pack of photographic film wrapped in a light-tight cover, which is used to measure cumulative radiation exposures for personnel monitoring. The badge may contain several films and filters to shield parts of the film from certain types of radioactivity. A film badge provides no protection against radiation.

Fission, Nuclear: A nuclear transformation characterized by the splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy.

Fusion, Nuclear: Act of coalescing two or more atomic nuclei.

Gamma Radiation: Short wavelength electromagnetic radiation emitted from the nucleus.

Geiger-Mueller Counter: Highly sensitive, gas filled radiation measuring device. It operates at voltages sufficiently high to produce avalanche ionization.

Genetic Effect of Radiation: Inheritable change, chiefly mutations, produced by the absorption of ionizing radiation.

Gray (Gy): A unit, in the International System of Units (SI), of absorbed dose which is equal to one joule per kilogram. 1Gy = 100 RADS

Half-Life, Biological: The time required for the body to eliminate one-half of an administered dosage of any substance by regular processes of elimination.

Half-Life, Radioactive: Time required for a radioactive substance to lose 50% of its activity by decay. Each radionuclide has a unique half-life.

Half Value Layer: The thickness of a specified absorber which, when introduced into the path of a given beam of radiation, reduces the exposure rate by one-half.

Interlock: A safety device, usually electrical and/or mechanical, to prevent activation of a control until a preliminary condition has been met, or prevent hazardous operations.

Internal Radiation: Radiation from a source within the body (as a result of deposition of radionuclides in body tissue).

Ion: Atomic particle, atom, or chemical radical bearing an electrical charge, either positive or negative.

Ionization: The process by which a neutral atom or molecule acquires a positive or negative charge.

Ionization Chamber: An instrument designed to measure a quantity of ionizing radiation in terms of the charge of electricity associated with ions produced within a defined volume.

Ionizing Radiation: Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.

Isotopes: Nuclides having the same number of protons in their nuclei, and hence the same atomic number, but differing in the number of neutrons, and therefore in the mass number. Almost identical chemical properties exist between isotopes of a particular element. Some isotopes are radioactive while other isotopes are stable.

Labeled Compound: A compound consisting, in part, of radioactively labeled molecules. By observations of radioactivity or isotopic composition, this compound or its fragments may be followed through physical, chemical, or biological processes.

Moderator: Material used to moderate or slow down neutrons from the high energies at which they are released.

Monitoring: Periodic or continuous determination of the amount of ionizing radiation or radioactive contamination present in an occupied region.

Natural Radioactivity: The property of radioactivity exhibited by more than 50 naturally occurring radionuclides. For comparison, the radiation exposure from natural background is approximately 220 mR per year in Colorado. This is about double the natural exposure at a typical sea level location, such as Beirut. There are three primary sources for this natural exposure. Cosmic radiation from space varies depending on the thickness of the atmosphere providing shielding, and around Denver it contributes about 60 mR per year. External terrestrial radiation arises from traces of natural uranium and thorium found in rock and soils worldwide, and around Denver it contributes about 140 mR/yr. Internally deposited radionuclides such as ^{40}K , a naturally occurring isotope present in all potassium, contributes about 20 mR/yr.

Neutron: An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen.

Nuclide: A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons (Z), number of neutrons (N), and energy content; or alternatively, by the atomic number (Z), mass number ($A = N + Z$), and atomic mass.

Personnel Monitoring: Monitoring any part of an individual, the breath, or excretions, or any part of the clothing.

Plated Source: A source of radioactive material plated permanently onto a sturdy backing to prevent dispersal. Similar to a Sealed Source, but plated instead of encapsulated to allow emission of less penetrating emissions such as alpha or beta particles.

Proportional Counter: Gas-filled radiation detection device; the pulse produced is proportional to the number of ions formed in the gas by the primary ionizing particle.

Proton: Elementary nuclear particle with a positive electrical charge equal numerically to the charge of the electron and a mass of 1.007277 mass units.

Quality Factor (QF): The linear-energy-transfer dependent factor by which absorbed doses are multiplied to obtain (for radiation protection purposes) a quantity that expresses – on a common scale for all ionizing radiations – the effectiveness of the absorbed dose.

Rad: A unit of absorbed dose of radiation of 100 ergs of energy per gram of absorbing material. 1 Rad = 0.01 Gy

Radiation: The emission and propagation of energy (or the energy propagated) through space or through a material medium in the form of waves.

Radiation Producing Machines: Machines that can emit ionizing or non-ionizing radiation. This includes but is not limited to; linear accelerators, Cobalt teletherapy machines, fluoroscopic machines, etc.

Radioactivity: The property of certain nuclides of spontaneously emitting particles or gamma radiation or emitting x radiation following orbital electron capture or of undergoing spontaneous fission.

Radiosensitivity: Relative susceptibility of cells, tissues, organs, organisms, or any living substance to the injurious action of radiation.

Radon Gas: A naturally occurring decay product of natural uranium and thorium in soils and rock worldwide.

Rem: A special unit of dose equivalent numerically equal to the absorbed dose in rads multiplied by the Quality Factor. 1 Rem = 0.01 Sv.

Roentgen (R): Unit of exposure defined as 2.58×10^{-04} coulombs per kilogram.

Scintillation Counter: The combination of phosphor, photomultiplier tube, and associated circuits for counting light emissions produced in the phosphors by radiation.

Sealed Source: A radioactive source sealed in an impervious container which has sufficient mechanical strength to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed.

Sievert (Sv): A unit, in the International System of Units (SI), of dose equivalent which is equal to one joule per kilogram. 1 Sv = 100 Rads.

Shield: A body of material used to prevent or reduce the passage of particles or radiation. A shield may be designated according to what it is intended to absorb (as a gamma shield or neutron shield), or according to the kind of protection it is intended to give (as a background, biological, or thermal shield).

Sickness, Radiation: The syndrome characterized by nausea, vomiting, diarrhea, and psychic depression, following exposure to intense acute doses of ionizing radiation, particularly to the abdominal region.

Specific Activity: Total activity of a given nuclide per gram of a compound, element, or radioactive nuclide.

Survey, Radiological: Evaluation of the radiation hazards incident to the production, use, or existence of radioactive materials or other sources of radiation under specific conditions. Such evaluation customarily includes a physical survey of the disposition of materials and equipment, measurements or estimates of the levels of radiation that may be involved, and sufficient knowledge of processes using or affecting these materials to predict hazards resulting from expected or possible changes in materials or equipment.

Thermoluminescent Dosimeter (TLD): A class of inorganic crystals which stores radiation energy through a process involving trapped electrons or holes. The stored energy can later be released as light through a heating process, the amount of light corresponding to the original absorbed radiation. Commonly used in personnel dosimeters such as finger rings, etc.

Waste, Radioactive: Solid, liquid, and gaseous materials from nuclear operations that are radioactive or become radioactive and for which there is no further use.

Wipe Smear: A sample made for the purpose of determining the presence of removable radioactive contamination on a surface. It is done by wiping, with slight pressure, a piece of soft filter paper over a representative type of surface area.

X-rays: Penetrating electromagnetic radiations emitted from the extra-nuclear part of the atom whose wavelengths are shorter than visible light.

Appendix B

Summary of Radiation health Risks

Exposure to radiation may be classified according to the quantity of exposure per unit time. Acute exposure is characterized by relatively high exposure of short duration, and may result in radiation sickness (symptoms: nausea, vomiting, diarrhea, hair loss, bruising, and psychic depression). Chronic exposure arises from relatively low exposures over months or years. A principal difference between a large acute exposure and low chronic exposure is that chronic exposure allows the body time to repair biological damage.

Much of the data on acute exposure has been obtained from nuclear weapons survivors from Hiroshima and Nagasaki. The expected biological effects of acute whole-body doses for healthy adults are briefly summarized as follows:

10 to 100 rads & 0.1Gy to 1 Gy	No obvious effect, except possible minor blood changes.
100 to 250 rads & 1 Gy to 2.5 Gy	Vomiting after 4 hours, lasting for several hours, fatigue.
250 to 400 rads & 2.5 Gy to 4 Gy	Vomiting within 1 hour, lasting for a day. Moderate lethargy. Skin reddening in a week and hair loss in 2 weeks. Death likely for 20% of exposed group. Survivors convalescent for several months.
400 to 600 rads & 4 Gy to 6 Gy	Vomiting within 1 hour, lasting for a day, fever, skin reddening, and loss of hair. Severe lethargy. Bruising at 3 weeks. Death likely for most of exposed group within a month.
600 to 1000 rads & 6 Gy to 10 Gy	Vomiting within 1 hour. Explosive diarrhea. Skin reddening. Fever. Death likely within a week.
> 1000 rads > 10 Gy	Severe radiation sickness, incapacitated almost immediately. Death within a few days at most.

The severe biological effects from large acute doses of radiation are unlikely to be encountered at the University due to the small amounts of radiation typically used. Of greater interest to the researcher would probably be any risks associated with chronic exposure to low levels of radiation.

Chronic exposures will typically be less than the 20 mSv (2 rem) annual limit (refer to Chapter 11) of the Nuclear Regulatory Commission (NRC). For most University researchers, a dose equivalent of 1 mSv (0.1 rem) might be acquired during a year of work. At this time, there have been no studies which have been able to determine the effects of human exposures this low with reasonable certainty. This is not due to lack of interest, in fact, radiation is probably the most studied of all toxic agents. Because the effects of low doses are small and difficult to distinguish from the effects of all other harmful agents in our lives, a scientific study requires data from large groups of exposed and un-exposed people. The

committee that studies the Biological Effects of Ionizing Radiation (BEIR) has estimated that a statistically significant study of the effects of a 1 mSv (100 mrem) dose equivalent would require 1,000,000,000 people.

The populations of the exposed groups and the control groups of the bomb survivors were large enough that the risks of radiation doses as low as 10 rads or 0.1 Gy per person can be predicted for sizable populations with relative certainty. Below 10 rads exposure there is very little human data and radiation effects at lower levels must either be projected downward from human data or predicted from studies with animals. Both extrapolation and the application of animal data to humans introduce uncertainty into the predicted effects.

To extrapolate downward several orders of magnitude one must make assumptions about fitting a line to the data. For radiation protection it is conservatively assumed the dose response curve is linear in shape and that any radiation exposure, no matter how small, presents some risk. This assumption, although seemingly common sense, has not been proven by scientific studies and may not be correct. It is common for many substances to be toxic at high levels, but to exhibit a low level threshold below which they are harmless or even beneficial to life, i.e., salt, some vitamins, trace elements, water, etc.. For this and several other reasons the scientific community considers the linear, non-threshold assumptions for extrapolation of data to be conservative for the purpose of radiation protection.

The end product of studies of several bodies of data from human and animal research using conservative extrapolation to lower doses can be expressed in terms of genetic risk and carcinogenic risk. 10 mSv (1 rem) per person before conception is expected to produce 5-75 additional genetic disorders per 1 million live births for the first generation. This is small in relationship to the usual incidence of serious genetic disorder of about 10% of live-born off-spring (90,000 per 1 million live-births). The risk estimates for cancer are only slightly larger. For 10 mSv (1 rem) per person per lifetime, it is estimated that about 100 additional fatal cancers may occur in a population of 1 million. This is small in relationship to the usual incidence of approximately 160,000 fatal cancers per 1 million people.

According to accident reports and other data for various occupations, the risk for radiation workers is generally less than that for practically any other occupation. This is based on an average annual dose of 6.5 mSv/year (0.65 rem/year) for 30 years. Since the average annual dose at the University is less than 1 mSv/year (0.1 rem/year), the risk from radiation exposure should be even lower. This does not mean that safety precautions should be ignored. Instead, precautions should be followed to keep exposures As Low As Reasonably Achievable (ALARA) in order to minimize any additional risk, just as one would for any other type of risk. The worker, after all, has the first line responsibility of protecting himself from radiation hazards.

Appendix C

Required List of Supplies to be Present in the Laboratory

The following supplies and equipment shall be ordered and shall be available for safe handling of radioisotopes:

- Absorbent paper – tray lining, bench top covering, fume hood lining
- Decontamination soap
- Disposable pipettes, syringes, and test tubes
- Forceps – various sizes
- Gloves – disposable polyethylene and latex (small, medium and large sizes)
- Lab coats – various sizes
- Pipette fillers and safety bulbs
- Safety glasses and goggles
- Tongs (crucible) – at Chem. Stockroom ONLY
- Warning Tape – “Caution – Radioactive Materials”
- Warning Tape – “Radioactive”

Some additional supplies shall be stocked in limited quantities by Health Physics Services, and are listed below:

- Counter cover – ribbed plastic sheet
- Shoe covers – vinyl, disposable
- Survey smears – numbered paper disc for room surveys
- Trays – plastic
- Warning labels – for posting the use of Radioactive Materials
- Lead shielding

For additional information, including vendors of radiation detectors, plastic shielding, etc., call extension 2360.

Appendix D

Tritium Contamination of Freezers

The accumulation of tritiated water (HTO) in the frost of freezers in which tritiated compounds are stored has been a problem of much concern to both the Health Physics Laboratory and to the researchers who use these compounds. In order to answer the most common questions concerning this problem, the following points should be noted:

- 1) Radioactive HTO exchanges with the stable hydrogen in water, or oxidizes to tritiated water vapor almost immediately upon escape from decomposing labeled compounds. Contamination accumulates in frosted freezers up to a concentration roughly proportional to the total activity stored in the freezer.
- 2) Confinement of HTO is extremely difficult. The only adequate container is a sealed glass ampoule. HTO will readily escape from other containers, such as screw-cap vials, multi-dose vials, and corked or para-film sealed vials.
- 3) The accumulation rate depends upon the type of containers used for storage, and the frequency with which they are opened. In an active lab that uses a moderate amount of HTO and stores samples in para-film sealed vials, contamination of the freezer frost can equilibrate in about a month. Due to tritium's long half-life (12.3 yrs) contamination may be present long after the labeled compounds are removed.
- 4) Containers stored in a frosted freezer will also develop frost on their exterior surfaces. They should be handled with disposable gloves, defrosted, and decontaminated before use. Frost on containers can often lead to cross contamination of solutions and contamination of lab surfaces.
- 5) For those research labs with frost-free freezers, precautions should still be observed. While HTO will not accumulate to the levels possible in a frosted freezer, there can be a film of frost buildup on the freezer walls. This film should be treated as would frost in a frosted freezer. Wipe smears of the freezer surfaces, especially around the vents should be taken every six months to insure a contamination free environment.
- 6) In response to questions concerning what actions should be taken for various levels of contamination, the following recommendations have been made:
 - A. 0-1,000 dpm/ml – Defrosting or cleaning is probably not needed, but it is wise to note the presence of contamination, and the possibility that the contamination could become more severe.
 - B. 1,000 – 10,000 dpm/ml – Defrosting, or cleaning in the case of frost free freezers, is recommended. If only small quantities (a few millicuries) of HTO are being stored, it will be possible to reduce the level to less than 1000 dpm/ml. If large quantities are in use, this may be the best that can be achieved. If requested, Health Physics Services will follow up your defrosting and decontamination procedures with a re-survey of the contaminated freezer.
 - C. 10,000 – 100,000 dpm/ml – Defrosting and decontamination is required. If there are specific items of high activity or long-term storage, they should be put in desiccators. Health Physics Services will follow up your defrosting and decontamination procedures with a re-survey of the contaminated freezer.

- D. 100,000 dpm/ml or greater – There has probably been a spill in the freezer. Call Health Physics Services. Defrost and decontaminate. Attempt to locate the source of the contamination.
- 7) When defrosting a freezer, the frost melt must be handled as liquid radioactive waste. A heavily frosted freezer could contain several millicuries of HTO in the frost. The recommended procedure is as follows:
- Open the door and switch to DEFROST.
 - When chunks of ice begin to loosen, put on disposable gloves and remove the larger pieces of ice. Change gloves frequently.
 - Place the ice in large beakers and let thaw in an adequately ventilated fume hood. Absorbent paper with a waterproof backing should be used to cover the bottom of the hood.
 - Blot up frost melt with disposable paper towels and place the towels in the hood to dry.
 - Place liquid frost melt in liquid radioactive waste containers. Place the dry paper towels in solid radioactive waste containers.
 - After all ice and residual liquid is removed, wash down the interior surfaces with a decontamination solution and disposable paper towels. Rinse and dry. Dispose of paper towels as in D and E above.
- 8) While it is recognized that an active user of tritiated compounds cannot expect a contamination-free freezer, there are some measures which can be taken to reduce the hazard to a minimum.
- Don't store large amounts of tritium that you don't need. In this regard, it is worthwhile to note that the stability of tritiated compounds varies widely. Many lose a significant fraction of their radioactivity over a period of months through exchange and decomposition. Compounds a year more old often are useless for research, but contribute to contamination hazards.
 - Properly store the tritium you do need. For large quantities of tritiated compounds (1850 MBq (50 mCi) or more) or for HTO that is used infrequently, storage in a desiccator is recommended. The desiccator should be defrosted frequently. The desiccant should be discarded in the solid radioactive waste, and replaced. If the desiccator is not sealed well after each opening, it will be ineffective in controlling contamination. For long-term storage of relatively stable tritiated compounds, such as tritiated water, sealed glass ampoules are recommended.
 - Check frost contamination levels frequently. If there is reason to believe that a hazard exists, or if you are just curious about it, survey it. A quick check requires only a milliliter of frost melt, a counting solution suitable for aqueous samples, and access to a liquid scintillation counter.
- 9) All refrigerators and freezers should be checked for residual contamination before being released for service or disposal. Call Health Physics Services at x2360 for a survey.
- 1 becquerel (Bq) = 2.703×10^{-11} curies
- 1 becquerel (Bq) = 2.703×10^{-8} millicuries

Appendix E

Conversion Factors

- 1 becquerel (Bq) = 2.703×10^{-5} microcuries
- 1 becquerel (Bq) = 2.703×10^{-2} nanocuries
- 1 becquerel (Bq) = $2.703 \times 10^{+1}$ picocuries
- 1 becquerel (Bq) = 1 disintegration per second (dps)
- 1 curie (Ci) = 3.7×10^{10} dps = 2.22×10^{12} dis/min. (dpm)
- 1 millicurie (mCi) = 3.7×10^7 dps = 2.22×10^9 dis/min. (dpm)
- 1 microcurie (μ Ci) = 3.7×10^4 dps = 2.22×10^6 dis/min. (dpm)
- 1 nanocurie (pCi) = 3.7×10^1 dps = 2.22×10^3 dis/min. (dpm)
- 1 picocurie (pCi) = 3.7×10^{-2} dps = 2.22 dis/min. (dpm)
- 1 pCi/liter = 37 Bq/m³
- 1 Bq/m³ = 2.7×10^{-11} μ Ci/cm³
- 1 μ Ci/cm³ = 1 μ Ci/ml = 2.22×10^{12} dpm/ m³ = 2.22×10^6 dpm/ml
- 1 roentgen (R) = 2.58×10^{-4} coulomb/kg
- 1 rad = 0.01 joule/kg
- 1 rad = 0.01 gray (Gy) = 10 mGy
- 1 mrad = 0.01 mGy = 10 μ Gy
- 1 gray (Gy) = 1 J/kg = 100 rad
- 1 mGy = 0.1 rad = 100 mrad
- 1 rem = 0.01 sievert (Sv) = 10 mSv
- 1 mrem = 0.01 mSv = 10 μ Sv
- 1 sievert (Sv) = 100 rem
- 1 mSv = 0.1 rem = 100 mrem

Appendix F

Low-Level Radioactive Waste Disposal

Low-Level Radioactive Waste DisposalThe disposal of low-level radioactive waste is regulated by the University Radiation Safety Committee. Ensuring compliance with these regulations is one of Health Physics Services jobs. Low-level radioactive waste can be separated into three broad classes; liquid, solid, and scintillation vials. There are a number of distinct sub-classes of these waste types that will be discussed below.

Health Physics Services will supply all of the containers necessary for proper disposal of radioactive waste materials. If you are just beginning work with radioactive materials, or your protocols are changing, please contact Health Physics Services for proper waste containers.

A. Liquid Waste:

Health Physics Services can supply containers to match the volume of liquid waste you expect to generate. Any liquids which are suspected of containing radioactive materials should be included in these containers. This would include the first wash of “hot” lab ware. Health Physics Services has a strict policy that no radioactive liquids may be poured down the drain.

To ensure compliance with the regulation we ask each lab to supply us with a list of all the chemicals that comprise their liquid radioactive waste. If you are just beginning work at AUB please supply a list of these chemicals to Health Physics Services. If you are currently working with radioactive materials please check your records for a copy of this list, check it for accuracy and forward a copy to HPL. If anything has changed, please update your list and forward a copy to Health Physics Services.

It is imperative that no restricted chemicals are placed into the liquid waste containers. The following is a very abbreviated list of some restricted wastes:

Methanol – Toluene – Formaldehyde – Acetone – Ethylether – Xylene – Isobutanol – Trichloroethylene – Metals (cadmium, lead, silver, chormium, etc.)

If you determine that any of these chemicals are essential to your experiments, we will work with you to locate acceptable substitutes or ensure proper disposal of your waste.

As a specific example, many labs were using Methanol in staining procedures. We have discovered that Ethanol or Isopropanol (both non-restricted wastes) are acceptable substitutes for methanol in these procedures.

Some frequent problems with liquid waste include: a) Overfilled containers, b) Liquid spilled into the outer container (trash can), c) Foreign materials, such as pipettes, syringes, etc. in containers.

B. Solid Waste:

This would include paper, plastic, and glass. Health Physics Services can supply a variety of containers for the disposal of solid waste, again depending on the volume of waste your lab will generate. Containers range in size from 20 gallon trash cans to five gallon buckets, to quart size, shielded bench-top containers.

As a general rule items that should not be placed into the solid waste containers include: sharps, lead pigs, excessive amounts of liquid, i.e. containers holding more than 10 ml of liquid, or large numbers of smaller liquid containers, scintillation vials, animals, blood. For example, centrifuge tubes holding more than 10ml of liquid must be emptied into the appropriate carboy and then placed into the solid waste.

For economic reasons, Health Physics Services will ask many labs to separate particular isotopes into distinct, clearly marked, containers. An example would be the separation of ^{32}P contaminated materials from solid waste contaminated with any other isotope or combination of isotopes. This waste is held for decay and subsequently disposed at a cost significantly below the low-level radioactive waste disposal rate. We shall provide containers, specially marked, for this purpose. Their size varies depending on the volume of waste generated by the lab. No other isotopes may be included within those containers marked for ^{32}P only. Containers for "mixed" isotope disposal are so marked on the waste disposal tag.

Some solid materials contain significantly larger amounts of activity than what is generated in a "normal" experiment. Health Physics Services may provide shielded waste containers for this highly active waste. For example, if you are working with amounts in excess of 185 MBq (5.0 mCi) of ^{32}P per experiment, and most of this activity will end up in the waste, please use shielded containers, for your safety and ours.

The following items are often mistakenly placed into solid waste containers. Health Physics Services has provided separate containers for the disposal of these types of waste.

Sharps: Any item that could cause an injury to AUB personnel should be disposed of properly. These items include, but are not limited to: razor blades, scalpels, syringe needles, and pasteur pipettes. Health Physics Services will supply small color marked containers designed specifically for the proper disposal of *sharps*. All of the above mentioned items, when they are contaminated by radioactive materials, should be placed into these containers. Sharps that are not contaminated by radioactive materials should be placed in an appropriate container for disposal. Keeping in mind that the current procedure for solid waste disposal places Health Physics Services personnel in close contact with your waste, it is especially important to dispose of *sharps* in the proper container.

C. Scintillation Vials:

Health Physics Services will supply containers for scintillation vials. All vials used for scintillation counting, regardless of size, should be placed in these containers. No other materials may be placed in these containers. Remember to use only biodegradable non toxic scintillation cocktails.

Health Physics Services has asked the labs to separate vials containing ^3H & or ^{14}C from those vials containing any other isotopes. The vial containers are clearly marked for this purpose. This separation allows the University to dispose of these vials at considerably reduced costs. Since ^3H and ^{14}C are considered to be of low toxicity to humans and since they do not present a significant external radiation hazard, waste disposal of these segregated isotopes will be less costly to the University.

For example; if your experiment involves a dual labeled sample of $^{32}\text{P} + ^{35}\text{S}$ these vials should be placed in the mixed vial container. If your experiment involves triple labeled samples of $^3\text{H} + ^{32}\text{P} + ^{125}\text{I}$, these vials should be placed in the mixed vial container. However, if your experiments involve ^3H or ^{14}C , separately or in combination, these vials should be placed in the vial container so marked.

If you have any questions about these procedures please feel free to contact Health Physics Services at ext. 2360. Thank you for your time and assistance.

Appendix G

Notes to New Licensees

LICENSING – An application for a license must be submitted to Health Physics Services and approved by the University Radiation Safety Committee before radioactive material may be ordered and work begins. This also applies to the use of radiation machines. In some cases, a request concerning a license may require amending the University’s license with the University Radiation Safety Committee. This amendment process usually takes about three months.

RADIATION SAFETY ORIENTATION – All radiation users must attend the radiation safety orientation and/or achieve a passing score on the radiation safety quiz. Sessions are offered a few times each year.

ORDERING RADIOACTIVE MATERIALS (RAM) – The request for a Purchase Order (PO) or Standing Purchase Order (SPO) must be approved and signed by Health Physics Services before it is sent to Purchasing Department. All material must be shipped directly to Health Physics Services. Health Physics Services will enter the new item into inventory, test for leakage, and deliver the package to the requesting laboratory.

LAB WORK AREA – Health Physics Services recommends that work with RAM be confined to a designated area of the lab and marked accordingly. If a sink is to be used for washing contaminated glassware, it should be labeled with a “Caution Radioactive Material” sign. Workbench liner paper, disposable gloves, trays, eye protection, lab coats, work shields, radiation detectors, etc. shall be used. All RAM material (vials, test tubes, etc.) must be labeled “radioactive” with the radionuclide and activity included.

SIGNS AND LABELS – Health Physics Services will provide signs and labels for posting the lab and storage area (probably the refrigerator). These signs and labels are required by University Radiation Safety Committee Regulations and shall not be removed or obscured.

MONITORING AND RECORDING – All radiation users must monitor their work area and record the results in the Survey Log provided by Health Physics Services. This log must be available for review at all times. All spills of radioactive material should be reported to Health Physics Services. If necessary, Health Physics Services will supervise decontamination. Health Physics Services also performs monthly surveys, but this does not in any way relieve users from their monitoring requirements. For sealed source or radiation machine users, external radiation must be checked with a suitable radiation detection instrument.

STORAGE AND INVENTORY – RAM should be stored in one place in the lab. This will usually be a refrigerator/freezer for most biochemical work. An inventory sheet will be posted and should be updated periodically as substantial amounts of the RAM stock are depleted. If H-3 is stored, it will tend to contaminate the moisture or frost. Health Physics Services will check for contamination each 6 months. If levels exceed 10,000 dpm/ml, the appliance **must** be defrosted and decontaminated (see appendix D of the Radiation Protection Handbook).

RADIATION DETECTION METERS – All labs using radionuclides with detectable energies (^{32}P , ^{35}S , ^{125}I , ^{33}P , etc.) and in sufficient quantities should purchase their own survey meter. Health Physics Services will calibrate the survey meter annually. Repair of these instruments can be accomplished at the Biomedical Engineering electronics shop.

DOSIMETERS – Each individual expected to receive in excess of 10% of the maximum permissible dose limit will be provided with a dosimeter. Film badges or TLD dosimeters are available for monitoring whole body exposure. These are personal monitors and should not be shared with anyone else. Contact Health Physics Services for an application.

SEALED SOURCES - Sealed sources of appropriate activity will be checked by Health Physics Services for leakage at 6 month intervals. Gas chromatographs contain sealed sources, if your lab owns a GC or intend to purchase one, please contact Health Physics Services prior to use of this instrument.

TRANSFER OF RAM OR RADIATION PRODUCING MACHINES – All transfers of RAM, whether across the University or across the country, must be made through Health Physics Services. Notification must be given at least 2 weeks in advance so that licensing and regulations may be considered.

RADIOACTIVE WASTE – Waste must conform to University Radiation Safety Committee regulations. Health Physics Services will provide containers for waste disposal. Waste must be segregated according to the following:

1. DRY SOLIDS – paper, plastic, glass (no hypo needles or capillary tubes)
2. ^{32}P DRY SOLIDS – If your experiments involve this single isotope, we ask that you separate solid materials solely contaminated with ^{32}P into the containers marked for such material.
3. AQUEOUS LIQUIDS – primary and secondary rinses. A complete and exhaustive list of all the chemical components of your liquid waste must be supplied to Health Physics Services before any waste will be picked up at your lab.
4. SCINTILLATION VIALS – Vials containing ^3H and ^{14}C are to be kept separate from vials containing all other radionuclides. Vials should be tightly capped.
5. BIOLOGICALLY HAZARDOUS MATERIALS (contaminated with radioactive materials) – These materials must be rendered non-hazardous or inert prior to inclusion in radioactive waste. Some indication must be visible, incubator tape, etc.
6. SHARPS – Razor blades, syringes, scalpel blades, pasteur pipettes, etc. must be placed in the containers specially provided for these materials.
7. Non-AQUEOUS LIQUIDS – Please contact Health Physics Services if it is absolutely necessary for your lab to produce these types of liquids. Separate containers will be provided for these materials.

Call X2360 a day in advance to request a pickup. Pickups are made on call basis. Please allow two weeks before a pick can be affected.

Appendix H

Survey Criteria and Procedure

A. SURVEY CRITERIA/PROCEDURES

a. Frequency/Result of Surveys

Laboratory surveys of all potentially contaminated surfaces should be performed by the user at the end of each workday or after each procedure, whichever is more frequent. Such surveys are REQUIRED monthly and after the use of open containers of significant quantities of radioactive materials. For some common radionuclides, significant quantities mean:

Greater than 185 MBq (5 mCi) for ^3H , ^{14}C , ^{35}S , ^{51}Cr , ^{99}Tc

Greater than 18.5 MBq (0.5 mCi) for ^{22}Na , ^{28}Mg , ^{32}P , ^{36}Cl , ^{45}Ca , ^{86}Rb , ^{125}I , ^{131}I

These values are for a single experiment or a series of experiment that add up to the specified values. Results of mandatory laboratory surveys must be recorded on a radioisotope facility survey form and kept for a period of 3 years. These results should be kept in a loose-leaf binder in a central area so that they will be available for inspection. Survey forms for specific laboratories may be obtained from Health Physics Services.

b. Locations to Be Surveyed

All areas where radioisotopes are used, stored or disposed and the floors adjacent to those areas must be monitored. Special attention must be given to areas that have high potential for contamination, such as: work benches, fume hoods, pipettes, syringes, centrifuges, door handles, refrigerators/freezers handles, drawers handles, chair edges, telephones, sink faucets, soap/towel dispensers, equipment handles and keyboards, etc.

c. Meter Survey Technique

For Beta emitters such as ^{14}C , ^{32}P , use a Pancake or a thin end window GM detector. For low energy Gamma emitters such as ^{121}I , use LEG. For medium and high energy Gamma emitters such as ^{131}I and ^{51}Cr , use HEG, Pancake or GM.

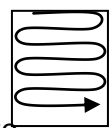
- Wear protective clothing such as lab coat, disposable gloves and safety glasses.
- Turn meter on.
 - Check the batteries by turning the selector switch to the BAT position.
 - Check the detector response by placing the detector window over a check source. The indicated response must be within ± 20 to 30% of that given on the calibration certificate.
 - Place the meter readout on the count per minutes (cpm) scale.
- Determine background count rate.
 - Stand clear off any radiation source (outside of the lab).
 - Set the scale multiplier to its lowest possible setting and the response button to fast. Turn the Audio on, if available.
 - While standing still, read background for approximately 1 minute. For a thin end window GM detector, normal background reading is between 20-40 cpm, while for a LEG is between 150-200 cpm.
- Begin surveying

- Hold the window of the probe within 1 cm of the surface to be monitored. In order to prevent the possible contamination of the probe, do not allow it to come in direct contact with the surface.
- Move the probe at a rate of 2 cm per second, while listening to the speaker. For meters without a speaker, observe the readout needle for rapid movement. Note that jerking of the probe may result in an erroneous count due to the electronic noise that is generated in the cable.
- Any location where a count is registered (audio sound and/or needle movement), must be examined. Place the window of the probe steadily over the location and observe the corresponding count rate. If the count rate is greater than three times the background, mark the contaminated area and proceed to decontaminate (refer to the decontamination section).
- Adjust the scale selector as needed. If the dial needle goes off scale due to the radiation level, switch the scale multiplier to the next higher level and press the reset button. This must be repeated as needed.
- Record results on a survey form, if required.

d. Wipe Survey Technique

Ideal for beta emitters, and may also be used for detecting low energy gamma emitters such as ^{125}I and ^{51}Cr , which also emits Auger electrons.

- Wear protective clothing such as lab coat, disposable gloves and safety glasses.
- Identify locations where contamination may be likely.
 - Key these locations with letters or numbers on the survey diagram.
 - Key each wipe to the identified location on the survey diagram. This can be done by labelling the cap of the vial into which the wipe will be placed.
- At each identified location, wipe an area of 100 cm^2 .
 - Wipe the entire 100 cm^2 surface by moving the wipe as shown in order to cover the whole area.
 - In order to avoid cross contamination between wipes, place each wipe into its appropriate vial, tube or planchet.
- For Liquid Scintillation Counting:
 - Add 5 to 10 ml of liquid scintillation cocktail into each vial. Secure caps on vials.
 - Include a background sample. A background sample is a vial that contains a clean wipe and liquid scintillation cocktail.
 - Place all vials, including the background vial into a counting tray.
 - The counter windows should be set according to the radioisotopes. One window should cover the entire energy range in order to detect the presence of unexpected radioisotopes.
- Record results on a survey form, if required.



B. Decontamination Criteria/Procedure

Radioisotope work surface areas and instruments with contamination levels greater than 3 times the background when surveyed with an appropriate survey meter must be

decontaminated. When using a liquid scintillation counter (LSC), work surface areas with contamination levels between 100 & 1000 dmp/100 cm² should be decontaminated. For contamination levels greater than 1000 dpm/100 cm², the HPS must be notified (2360) and decontamination is required. When a survey meter and LSC is used, then the stricter criteria apply. Other areas such as floors, desks, telephones, computer keyboards, doorknobs, etc must be contaminated free at all times.

Two personnel should perform the decontamination procedure. One should do the actual cleaning while the second should perform the monitoring.

- Wear personal protective equipment such as lab coat, disposable gloves and safety glasses.
- Mark the contaminated area.
- Spray the contaminated surface with detergent such as "Count-Off" or "Isoclean", allow the detergent to settle for several minutes. Do not allow the detergent to drip onto other surfaces as it may result in cross contamination.
- Wipe only the effected area with paper towel, place it in plastic bag and dispose off as radioactive waste. Exercise care not to cross contaminates other surfaces.
- Survey the disposable gloves and change them as appropriate.
- Survey the contaminated area as appropriate.
- Continue decontaminating and resurveying until the above stated criteria is met.
- If after repeated decontamination, the contamination levels did not meet the acceptable criteria, label the contaminated surface with a radiation sign and contact Health Physics Services for further instructions.
- Monitor all personnel involved in the decontamination procedure before leaving the area.

Appendix I

Radiation Safety Policy Pertaining To Iodine Therapy

A. ENDOCRINOLOGY PERSONNEL / HEALTH PHYSICS SERVICES

- All personnel who are involved with iodine therapy must attend a radiation safety training session that is provided by the Health Physics Services (HPS) before they are allowed to participate in the iodine procedure.
- Patient cooperation is extremely important in minimizing unnecessary incidents and exposure to personnel, relatives, and other members of the general public. It is therefore essential that the patient is given a careful explanation by his/her physician as to the nature of the treatment and the procedures involved.
- It is the responsibility of the physician in charge to see that radiation safety guidelines are carefully followed.
- Before iodine is administered to a patient, the patient's doctor must provide verbal and written instruction (Instruction to Patients Receiving Iodine-131 pamphlet) to the patient. These instructions will help to reduce contamination and to keep radiation dose to household members and the public as low as reasonably achievable (ALARA).
- Patient receiving iodine treatment shall be quartered alone in a private room.
- Only qualified endocrinology personnel, who have received radiation safety training, shall perform the administration of iodine. All personnel who are involved in the administration or preparation of iodine must wear a film badge and a TLD ring and must report to HPS within 24 to 72 hours after the administering of iodine for a thyroid bioassay.
- All doses greater than or equal to 1110 MBq (30 mCi) must be administered in the patient's room. The vial containing the iodine capsule must be vented in a fume hood before being transported to the patient room. Endocrinology personnel must transfer the iodine capsule in a lead-shielded container to the patient's room. The most direct route with the least occupied areas should be used. Personnel who are involved with the transport of the iodine must wear a film badge and a TLD ring.
- Prior to iodine administration, the activity of the iodine must be measured by the use of a dose calibrator. If the measured dose differs from the prescribed dose by more than 10 percent, contact the patient physician and HPS for further instruction. Records of these measurements must be maintained for a period of three years and must contain the following information:
 - Name of radiopharmaceutical.
 - Patient's name.
 - Prescribed dosage and activity of the dosage at the time of measurement.
 - Date and time of measurement.
 - Initials of the individual who made the record.
- The administration of iodine capsule must be performed as follow:
 - Remove the lead container from the transport box and put it on the table close to the patient, then stand at least 2 meters away.
 - Have the patient remove the vial from the lead container and take the capsule.
 - After the administration of the capsule, the patient should take a hot drink.

- The door of the patient's room must be posted with a removable sign that consists of the radiation symbol and the following text in English and Arabic: "Caution Radioactive Materials", "No Visitors Allowed".
- For patients receiving 1110 MBq (30 mCi) or more, immediately after the administration of iodine, the dose rate must be measured at 1 and 2 meters from the patient, and at the adjacent areas as specified in the Iodine Therapy Survey Form, with the results of the survey recorded in the form. The exposure level at one meter from the patient must also be measured daily with the result entered into the form, until the measured dose rate is less than 5 mR/h.
- Radiation levels outside of the iodine patient room shall be maintained less than 2 mR/h in the corridor and less than 0.6 mR/h in adjacent occupied rooms.
- Iodine patient shall not be discharged unless the patient contain less than 1110 MBq (30 mCi) of iodine-131 or the dose rate at one meter from the patient is less than 50 μ Sv/hr (5 mrem/h).
- After patient's discharge, the patient's room must be surveyed for contamination. Prior the release of the room for another iodine patient, removable contamination must be less than 2,000 dpm per 100 cm² and fix contamination less than 10,000 dpm per 100 cm².

B. NURSING STAFF

a. Educational Requirements

All personnel caring for patients undergoing iodine therapy must attend on annual basis the radiation safety instructional session that is provided by Health Physics Services (HPS). These personnel shall be familiar with all of the information provided in this guideline. A copy of this guideline shall be kept at the nurse's station. Additional lectures may be provided by HPS upon request.

b. Instructions

Radioactive iodine will appear in the urine, saliva, perspiration, tears, and other body fluids, so without compromising patient care, the following instructions must be strictly adhered to:

- Personnel are encouraged to consult HPS for any questions that pertain to radiation safety.
- Nurses should review the "Radiation Safety Policy Pertaining to Iodine Therapy" before radioactive iodine is administered to the patient.
- The patient must be admitted to room 845 and confined to his/her room except for special medical or nursing purposes approved by his/her doctor *and* HPS.
- All personnel caring for patients undergoing iodine therapy must wear a dosimeter.
- Personnel that are pregnant or under the age of 18 shall not enter the patient room.
- All personnel entering the room must wear impermeable gloves and shoe covers. Disposable gloves and shoe covers must be positioned outside of the patient room and a designated waste container is to be positioned inside the room, next to the door. The

gloves and shoe covers must be removed and disposed of in the designated waste container before leaving the room. Shoe covers should be removed first while still wearing the gloves. After removing the gloves and leaving the room, hands must be washed.

- Disposable items must be used in the care of iodine patients. Left over food and eating utensils must be placed in a closed plastic bag. No item is to be removed from the patient's room before the approval of HPS.
- The patient should be encouraged to drink plenty of fluids to promote urination and to flush the toilet 3 times after each use. Patients should also be instructed to wash their hands in plenty of warm, soapy water after each use of the toilet. Male patients must be instructed to sit-down when urinating in order to avoid splashing.
- For routine nursing care, only the minimum required time should be spent near the patient. The distance between personnel and the patient should be maximized but to a point where it still allows the appropriate care to be given. Lead shields should be used whenever it is possible.
- If a nurse, attendant, or anyone else knows or suspects that his/her skin or clothing, including shoes, is contaminated, HPS should be notified immediately. This person should remain in an area adjacent to the patient's room and should not walk about the hospital. If hands become contaminated, they must be washed immediately.
- If urine from a patient is to be collected, HPS should be contacted first. The patient should collect his/her own urine. If the patient is bedridden, a separate urinal or bedpan should be provided. The urinal or bedpan must be flushed several times with hot soapy water after each use. Utmost precautions must be taken to see that no urine or vomit is spilled on the floor or bed.
- Surgical dressings should be changed only as directed by the physician and in the presence of HPS. These dressings must remain in the room until they are monitored by a radiation survey meter for contamination. These dressings should be handled only with tongs or tweezers.
- Bed baths shall not be given.
- All bed linens and clothes used by the patient shall be placed in a plastic bag and checked with a radiation survey meter before being removed from the patient's room.
- Housekeeping must not enter the room unless under the direct supervision of the HPS.
- Visitors are not allowed.

EMERGENCIES

c. Medical Emergencies

Notify immediately the attending physician and the Health Physics Services (HPS) if the patient has any medical emergencies. Life-saving procedures should be initiated immediately without concern for radiation exposure while attempting to take precautions against the spread of contamination. Direct contact with the patient's mouth should be avoided and all members of the emergency team must wear impermeable protective gloves. Body fluids collected from the patient must be labeled "Radioactive" and the receiving laboratory must be notified. For emergencies that are not immediately life threatening, the advice of HPS must be sought on methods of reducing radiation exposures.

d. Aggravated/Uncooperative Patient

Contact the patient's attending physician and HPS if consistent patient behavior results in having the nursing staff repeatedly attend and calm the patient or to keep him/her from leaving the room, resulting in unnecessary exposure to personnel.

e. Spillage of Radioiodine or Body Fluids

Spillage of an iodine patient body fluid (vomitus, incontinence, excessive sweating) will result in contamination of the area. If such contamination occurs while attending to the patient, the following steps must be followed.

- Keep calm and cover the spill with absorbent pads to contain the liquid.
- For all personnel in the room, excluding the patient, go to the door and take off your shoe cover. Close the door after leaving the room and remain by the door.
- Call the nursing station for assistance. If no one can hear, one person only should walk no further than is necessary to find someone to call HPS.
- Remove immediately any contaminated clothing and place it in a large plastic bag.
- Wash any contaminated skin with a mild soap and plenty of water; do not use a hard brush, or abrasive soap.
- Wait for the arrival of HPS personnel.

f. Emergencies Contacts

In case of an emergency, contact only one of the listed personnel. Start by contacting the first listed name. If not reachable, contact the second one, and so on.

- Mr. Mohamad Houssam Tamim, University Radiation Safety Officer, ext. 2378, pager: 0038, phone number: 03-909-113.
- Ms. Safa'a Mourad, Radiation Protection Specialist, ext. 2367, pager: 0065.
- Mr. mohamad Haidar, Radiation Protection Specialist, ext. 2363, pager: 0037.

INSTRUCTIONS TO PATIENTS RECEIVING IODINE-131

IF YOU HAVE ANY QUESTIONS, PLEASE ASK YOUR DOCTOR		
YOUR DOCTOR WILL BE PLEASED TO REFER YOU TO RADIATION SAFETY PERSONNEL IF NECESSARY. FOR THE SAFETY OF OTHERS, PLEASE FOLLOW THE GIVEN INSTRUCTIONS AND ANY OTHER INSTRUCTIONS GIVEN BY YOUR DOCTOR.		
Precaution	How Long After Discharge From The Hospital?	
	< 259 MBq (7 mCi) of I-131	> 259 MBq (7 mCi) of I-131
Try to keep the time you spend in close contact with others to a minimum. Sleep alone. Avoid kissing and sexual contact of any kind.	4 days	8 days
Try particularly to minimize time spent with pregnant women and young children.	4 days	8 days
Drink plenty of liquids.	1 day	1 day
Use good hygiene habits. Wash your hands thoroughly after each toilet use. Males should sit when urinating, to avoid splashing. Flush the toilet 2 to 3 times after each use.	2 weeks	2 weeks
Use separate eating utensils. Avoid sharing food, glasses, bottles, cans of soda, etc.	1 week	1 week
Use separate towels and washcloths. Wash bath-towels, bed sheets and underwear separately.	1 week	1 week
Cease breast-feeding.	Complete cessation for this infant or child	
Discuss how long you should wait before starting a pregnancy after your treatment.	6 months for females 2 months for males	

إرشادات للمرضى المعالجين باليود 131

إذا لديك أي سؤال، اسأل طبيبك		
إذا لزم الأمر سوف يرشدك الطبيب لمقابلة اختصاصي السلامة من الأشعة. لسلامة الآخرين، نرجو اتباع هذه الإرشادات بالإضافة إلى إرشادات الطبيب.		
لأي مدة بعد مغادرة المستشفى؟		الاحتراس
أقل من 259 MBq (7mCi) من اليود 131	أكثر من 259 MBq (7 mCi) من اليود 131	
4 أيام	8 أيام	حاول أن تبقى بعيدا عن الآخرين قدر الإمكان. نام منفردا. تحاشي التقبيل والاتصال الجنسي من أي نوع.
4 أيام	8 أيام	تحاشي أن تجالس الحوامل والأطفال.
يوم	يوم	اشرب الكثير من السوائل.
أسبوعين	أسبوعين	اتبع العادات الصحية جيدا. اغسل يديك جيدا بعد استعمال المرحاض. على الذئور الجلوس أثناء التبول لمنع تناثر البول. شغل المرحاض مرتين أو ثلاثة بعد الاستعمال.
أسبوع	أسبوع	استعمل أدوات خاصة بك لتناول الطعام. تجنب مشاركة الآخرين الطعام والأقداح... والقناني
أسبوع	أسبوع	استعمل مناشف خاصة بك و اغسل مناشفك، شراشفك وملابسك الداخلية مرفصلة عن غسيل الآخرين.
الامتناع نهائيا عن إرضاع الطفل الحالي		امتنعي عن الإرضاع.
6 أشهر للإناث شهرين للذكور		اسأل طبيبك عن المدة اللازمة لانتظار قبل بدء الحمل بعد المعالجة.

Appendix I

Irradiation of Blood Component: Quality Assurance & Standard Operating Procedure

I. Quality Assurance

The blood irradiation system must be safe and effective and prevent, detect and correct deficiencies that may compromise blood quality.

A. Process Validation

i. Absorbed-Dose Mapping

For each blood product treated, there is a minimum dose to achieve the desired effect and a maximum dose that the blood product can tolerate without degradation in quality. Absorbed-Dose Mapping is used to determine the magnitude and locations of the maximum and minimum absorbed dose for a given set of loading configuration. This information is then used, with other data, to determine the required irradiation time to give an absorbed dose of 25 Gray (2500 rad) to the central portion of the container, a maximum and a minimum dose of 50 Gray (5000 rad) and 15 Gray (1500 rad) to any other points. The Health Physics Services performs Dose Mapping annually; additionally, after repair to turntable system and/or when the irradiation is relocated.

ii. Dosage Time / Adjust for Decay

The reduction of source intensity with time due to radioactive decay of the Cesium-137 source and hence the corresponding increase in the required irradiation time is performed annually by Health Physics Services. The timer setting is increased by 1.02% annually and a label indicating the required irradiation time is affixed on the irradiator by the Health Physics Services.

iii. Radiation Sensitive Indicators

Radiation Sensitive Indicator is a material that may be affixed to the blood product and which undergo a visual change when exposed to ionizing radiation. In order to assure that each blood product has received the minimum required irradiation, an indicator must be used with each blood product.

iv. Blood Temperature

Blood products that have spent time out of the controlled storage environment during the irradiation procedure for over 20 minutes must be monitored to prevent the warming of the red cell products above 10⁰C and platelet products to remain in the range of 20 to 24 ⁰C.

v. Shelf Life

The Self-life is the maximum allowable storage time for a blood component held under acceptable storage temperatures and conditions. The shelf life for red blood cell products may not be more than the original outdate (expiry date from the time of collection) or 28 days from date of irradiation, whichever is sooner. The shelf life for Irradiated platelets is same as for the non-irradiated platelets. On each blood unit, the shelf life to the unit must be clearly indicated.

B. Quality Control

Equipment used in the production of irradiated blood components must have routine quality control testing.

i. Timer & Turntable

The irradiator timer and the turntable must be checked at the beginning of each day of use.

- a. Set the timer to the specified irradiation time.
- b. Open the irradiator door, rotate the sample chamber by hand until the sample can cutout is accessible. Place the sample canister, with its lid on, in the center of the chamber.
- c. Close the irradiator door and lock it by turning the door handle fully counter clockwise.
- d. Get ready the stopwatch and press the IRRADIATE Bottom. Start the stopwatch when the IRRADIATE light is illuminated.
- e. Stop the stopwatch when the IRRADIATE light is turned off.
- f. Record the results in the “Irradiator Daily Usage Log Form”. If the measured irradiation time differs from the preset timer by more than 4 seconds, calls Health Physics Services immediately.

ii. Leak Test

As with any other sealed source of radioactive materials, the irradiator must be checked for radiation leakage. Leak tests are performed by the Health Physics Services staff every six months in accordance with the manufacturer recommendations. Documentation of the leak test is kept with the Health Physics Services and a copy at the Blood Bank.

iii. Radiation Sensitive Indicators

Exposure of radiation sensitive indicators to unfavorable environmental conditions such as heat, daylight, ultraviolet radiation and gases may result in false positive or negative observations. For this reason, indicators must be stored in proper conditions as listed below and in accordance to the manufacturer’s direction.

- a. When a new lot of indicators are received, check the Temperature Indicator Card and whether the word “**NOT**” is clearly visible in the window of each indicator, and record the results in the “Radiation Sensitive Indicators Log Form”. If the Temperature Indicator is not acceptable, or if the word “**NOT**” is not clearly visible, do not use the Radiation Sensitive Indicators, inform your supervisor and Health Physics Services immediately.
- b. Return the Temperature Indicator Card to the box and keep it with its lot of indicators.
- c. Always keep the unused indicators in their original box. Keep the box lid closed in order to avoid prolonged exposure to light.
- d. Store the indicators at a temperature between 0⁰C and 6⁰C and away from gases, heat and radiation sources.

Documentation is to be kept in the “Radiation Sensitive Indicators Log Form”.

C. Record Keeping

Records that document the significant steps in the irradiation of each component including identification numbers must be maintained. These records will be reviewed by Health Physics Services. For each batch of blood component, the following information shall be recorded in the “Irradiator Daily Usage Log Form”:

- i. The serial number of the blood unit.
- ii. The Patient name.
- iii. The referring physician and the institution.
- iv. The irradiation dose and time.
- v. The identity of the person performing the irradiation.
- vi. The date and time of the irradiation.
- vii. Length of time the blood component was out of controlled storage.

Note: If the blood unit is latter not transfused to the patient, indicate so on the form.

References:

- FDA:** Gamma Irradiation of Blood and Blood Components, A Pilot Program For Licensing.
ASTM: Standard Practice for Blood Irradiation Dosimetry
USNRC: 10CFR35
RAD-SURE: Blood Irradiation Indicator Use Instructions.
JLShepherd & Associates: Model 143 Cesium Laboratory Irradiators.

II. Standard Operating Procedure For Irradiation of Blood Components

A. Purpose

The procedure listed below is to be used in the licensing, training and use of the self-contained, self-shielded, Gamma Irradiator for the irradiation of blood components.

B. Authorization

The Gamma Irradiator is to be used only by properly trained blood bank personnel who in the addition of their departmental training, have been trained by Health Physics Services in the proper operation and safety procedures.

C. Irradiation of Blood Components Procedure

- a. Set the timer to the irradiation time specified on the calibration label affixed to the irradiator.
- b. Remove a sheet of the Radiation Sensitive Indicators from the box. Look for the word “**NOT**” in the window of each indicator. If the word “**NOT**” is not clearly visible, do not use the indicator.
- c. Check the expiration date of the indicator, if expired do not use.
- d. Enter the date and operator’s initials in the spaces provided on the indicator.
- e. Peel the indicator from its backing by bending the sheet. Avoid touching the adhesive layer with rubber gloves.
- f. Apply the indicator firmly to the middle of the blood unit. The location where the indicator is applied must be clean and dry.
- g. Place the blood unit upright in the center of the stainless steel canister. Make sure that no part of the blood unit extends outside of the canister. Close the canister with its designated lid.
- h. If two blood units are to be irradiated at the same time, place both units upright, back to back. A maximum of two units may be irradiated at any one time.
- i. Return any remaining indicators to their box, close the lid and return the box to its storage place.
- j. Open the irradiator door and rotate the sample chamber by hand until the sample can cutout is accessible. Place the sample canister in the center of the chamber, making sure that no part of the canister or any part or appendage of the blood unit extends beyond the chamber opening in the drawer.
- k. Close the irradiator door, lock it by turning the door handle fully counter clockwise and start the irradiation by pressing the “IRRADIATE” button.
- l. After irradiation is complete, the Buzzer will sound. Press the reset button, open the irradiator door and remove the canister.
- m. Check the indicator to verify that the window is black and the word “**NOT**” is obscured. If the word “**NOT**” remains visible, notify your supervisor immediately. In this case, the supervisor must follow the following steps:
 - i. Set the irradiator timer to 1 minute.

- ii. Put back the sample in the canister as described above and irradiates it for an additional minute **ONLY**.
- iii. After irradiation, check the indicator; if the word “**NOT**” remains visible notify the Health Physics Services immediately.
- n. Record the results in the “Irradiator Daily Usage Log Form” form. Make sure that all of the following information is entered correctly: The serial number of the blood unit, the Patient name, the referring physician and the institution, the irradiation time and dose, the identity of the person performing the irradiation, and, the date and time of the irradiation.
- o. Return the RBC unit to the refrigerator (if the blood unit was outside of the refrigerator for over 20 minutes check and record its temperature).
- p. Return the platelet unit to the environmental chamber.
- q. The indicator must remain affixed on the blood unit at all times. If for some reason the indicator is removed, another label must be placed on the unit or clearly indicate on the unit that it has been irradiated.
- r. Note that the maximum dating period for red blood cell products may not be more than the original outdate or 28 days from date of irradiation, whichever is sooner. Irradiated platelets will have the same expiration date as non-irradiated platelets.

Note that the indicators must be stored as per the manufacturer recommendations.

References:

JLShepherd & Associates: Model 143 Cesium Laboratory Irradiators.

FDA: Gamma Irradiation of Blood and Blood Components, A Pilot Program For Licensing.

RAD-SURE: Blood Irradiation Indicator Use Instructions.

Appendix K

Radioactive Material Receipt Procedure

1. Wear lab coat and disposable gloves.
2. Inspect the package for signs of damage (crushed, wet, discoloration). If damage is noted, stop the procedure and notify the Health Physics Services (HPS).
3. Place package on an absorbent paper with plastic backing.
4. For volatile radioactive material, place package in vented hood on absorbent paper with plastic backing before opening.
5. Measure the exposure rate at 1 meter and at the surface. Record the results on the Radioactive Material Receipt Form. If the exposure rates are higher than those listed below, stop the procedure and notify HPS.

Package Label	Exposure Rate at Surface (mR/hr)	Transportation Index (mR/hr at 1 m)
White I	0.5	NA
Yellow II	0.5 to 50	TI < 1
Yellow III	50 to 200	1 < TI < 10

6. Wipe the external surface of the shipping container. Take at least 3 wipes with each wipe covering 100 cm². Count the wipes with an appropriate counting system (for isotopes that do not emit a low energy beta, you may use a hand held detector, however if contamination is found, the contamination must be quantified by the use of an appropriate counting system). Document the wipe results. If the removable contamination is greater than 2200 dpm for a gamma or beta emitting nuclides or 220 dpm for alpha emitters, stop the procedure and notify HPS.
7. Remove the packing slip and open the outer package following the supplier's instructions, if provided, and remove the inner package that contains the radioisotope.
 - a. For all isotopes excluding ³H, move the outer package to an area with a low background radiation level and carefully monitor the interior and the exterior of the package with an appropriate survey meter. If no contamination is detected, remove or obliterate any radiation labels before discarding it in the normal trash. If contamination is detected, handle as radioactive waste.
 - b. For ³H labeled compounds, wipe the package locations where it is most likely that contamination may occur. Read the wipe with a LSC. After receiving the wipe results, handle the packaging material as appropriate.
8. Wipe the outside of the inner package and read with an appropriate instrument. Record the results. If the removable contamination is greater than 2200 dpm for a gamma or beta emitting nuclides or 220 dpm for alpha emitters, stop the procedure and notify HPS.
9. Open the inner package and verify that the contents agree with the packing slip.

10. Check the integrity of the final source container. Look for broken seals or vials, condensation, or discoloration of the packing material. If things are as they should be, place the final source container in the inner package, close the inner package, and then fill the appropriate form.
11. Notify and arrange with the final user a delivery time.
12. Record results on the Radioactive Material Receipt Form.

Appendix L

Radioactive Material Transfer Procedure

1. Wear lab coat and disposable gloves.
2. Inspect the radioactive material source (or device) for signs of damage. If damage is noted, stop the procedure and notify the Health Physics Services (HPS).
3. Place the source on an absorbent paper with plastic backing.
4. Leak tests the source as per the NRC/manufacture recommendations and record the results on the “Radioactive Sealed Source Transfer Form”.
5. If the leakage test reveals the presence of 0.005 microcurie or more of removable contamination contact HPS immediately.
6. If the leakage results were less than 0.005 microcurie, place the source in its shipping container. Use the original shipping container and follow the supplier’s instructions if available.
7. Measure the exposure rate at 1 meter and at the surface of the shipping container. Record the results on the “Radioactive Sealed Source Transfer Form”. Make sure that the shipping container is labeled as listed below.

Package Label	Exposure Rate at Surface (mR/hr)	Transportation Index (mR/hr at 1 m)
White I	0.5	NA
Yellow II	0.5 to 50	TI < 1
Yellow III	50 to 200	1 < TI < 10

8. Wipe the external surface of the shipping container. Take at least 3 wipes with each wipe covering 100 cm². Count the wipes with an appropriate counting system (for isotopes that do not emit a low energy beta, you may use a hand held detector, however if contamination is found, the contamination must be quantified by the use of an appropriate counting system). Document the wipe results. If the removable contamination is greater than 2200 dpm for a gamma or beta emitting nuclides or 220 dpm for alpha emitters, stop the procedure and notify HPS.
9. Contact and inform HPS of your intentions to return the sealed source to its supplier at least 48 hours in advance.
10. Prior the receipt of the source by the supplier, the supplier must sign the “Transfer of Custody Form” in the presence of HPS personnel.

Appendix M

The 10-Day Rule for Potentially Pregnant Patients

