Montreal Neurological Institute
and Hospital

A Teaching and Research Institute at McGill University

Radiation Safety Manual for Nuclear Substances, Radiation Devices And Cyclotron (Class II) Facilities

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Montreal Neurological Institute and Hospital
A Teaching and Research Institute at McGill University

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1. INTRODUCTION

The International Commission on Radiological Protection (ICRP) has recommended a philosophy of radiation protection based upon quantitative risk. The basic system was set forth in Recommendations of the ICRP, ICRP Publication 26, Publication 57, p. 9 and Publication 60:

"The primary aim of radiological protection is to provide an appropriate standard of protection for man without unduly limiting the beneficial practices giving rise to radiation exposure. In summary, the Commission recommends the adoption of a system of dose limitation based upon the following principles:

(a) Justification of the practice: no practice shall be adopted unless it results in a positive net benefit.

(b) Optimization of Protection: all exposures shall be kept As Low As Reasonably Achievable, economic and social factors being taken into account.

(c) Dose limits: the dose equivalents to the individuals shall not exceed the limits recommended for the appropriate circumstances by the Commission."

Every rule and recommendation in this manual is set in accordance with these fundamental principles of radiation protection.

1.1 Purpose of the Manual

This manual constitutes a handbook of procedures for the safe handling and application of sources of ionizing radiation for Nuclear Substances and Radiation Devices (NSRD). The manual also includes procedures for our cyclotron facilities (Class II).

The rules, recommendations and information included in this manual have been submitted to the Radiation Safety Committee as the basis of radiation safety for NSRD and Cyclotron facilities at the Montreal Neurological Institute and Hospital (MNI/H). The overall intention of these rules and recommendations is as follows:

a) Protection of staff, patients and the general public from the hazards associated with the use of ionizing radiation sources of all kinds.

b) Compliance with federal, provincial and local laws, regulations and licensing requirements related to such sources.

1.2 ALARA Principle

The guiding principle throughout this manual is the ALARA Principle which demands that the doses received by workers and members of the public be kept As Low As Reasonably Achievable, social and economic factors taken into account (see CNSC Regulatory Guide G-129, revison 1).

Adherence to the ALARA Principle is demonstrated by the following elements:

1) A demonstrated commitment from the management of the MNI/H towards radiation safety (awarding of a budget for radiation safety, appointment of a RSO and a RSC and a continuing interest in their activities, delegation of a representative from the administration to the RSC, continuing interest and support for upgrading radiation safety, purchasing and renewal of equipment)

2) The provision of resources (see under 1), organization and support of training sessions, establishment of "action levels" (efforts are continuously made to further reduce radiation doses to employees and to the environment), proper documentation of all radiation safety related data and events

3) Regular operational reviews of dose records, frequency of incidents (contamination control), review and introduction of new technology for improved radiation protection.

Notes:

- Throughout this manual "shall" is used to designate features or actions that are essential, while "should" is used to designate features or actions that are recommended.
- This manual will be amended and supplemented from time to time in the light of changes in knowledge, equipment, organization or legal requirements.
- All quantities in this manual are in the Système International (SI) units.

2. Organization and Responsibilities

The licensee of our current CNSC licenses is the Montreal Neurological Hospital & Institute. The management of the MNH/I is thoroughly committed to radiation safety as demonstrated by its assumption of the following responsibilities:

1) Provision of a radiation safety budget
2) Appointment of a radiation safety officer (RSO)
3) Provision of physical resources (space) for the radiation safety program
4) Requesting operational reviews from time to time

The organizational basis of radiation safety at the Montreal Neurological Institute and Hospital is as follows:

a) A Radiation Safety Committee initially appointed on the advice of the Director of the Montreal Neurological Institute and the Associate Executive Director of the MNH/MUHC.

b) A Radiation Safety Officer who reports to and works under the general directives of the Radiation Safety Committee.

c) Responsible Radiation Users, who are persons officially designated, for licensing and other purposes, as the individuals responsible for the procurement and use of specified radiation sources.

d) Departmental Radiation Supervisors who, in co-operation with Heads of Departments and Directors of Laboratories and with the Radiation Safety Officer, ensure compliance with the relevant radiation safety requirements within a defined geographical or departmental area.

e) Individual members of laboratories or departmental staff who have the responsibility of using radiation sources in such a way that they do not endanger themselves or other people.

2.1 Radiation Safety Committee (RSC)

2.1.1 Membership of the RSC

The membership of the RSC is chosen such that all major radiation user groups at the MNH/I are represented. These include in-vitro and animal research laboratories, radiochemistry cyclotron operations, PET research and nuclear medicine operations. Furthermore, in addition to the RSO, representatives from the administration, radiology, security, McGill University radiation safety and MUHC radiation safety are included as well. At present, the RSC consists of 13 voting members. The quorum for meetings therefore is 7 members.

The RSC has access to an administrative assistant who organizes the meeting dates, takes minutes and distributes them to the members of the RSC as well as to the Director of the MNI, the Associate Executive Director of the MNH/MUHC as well as to the CNSC.

2.1.2 Terms of Reference of the RSC

a) To review up to 4 times a year or whenever necessary, the matters and problems arising from the use of ionizing radiation in the Montreal Neurological Institute and Hospital in diagnosis, therapy and research, with a view to ensuring satisfactory standards of safety for patients, staff and the general public.

b) To ensure that radiation equipment, sources, handling and shielding procedures and safety standards satisfy such legal requirements and/or recommendations as may be issued from time to time by national, provincial and municipal regulatory authorities.

c) To review and to approve, or disapprove, the use of radioisotopes and radio-pharmaceuticals in the Institute and Hospital for both human and non-human applications, from the standpoint of radiation safety; to authorize the acquisition of these materials through the license holder; where necessary, to apply additional conditions to such use, other than those stated in the relevant license; and to suspend such use where appropriate, irrespective of the source of the original authorization.

d) To review and to approve, or disapprove, requests for the acquisition, installation and housing of equipment capable of producing ionizing radiation, from the standpoint of radiation safety.

e) To review arrangements for the disposal of radioactive waste, including unused radioisotopes and radio-pharmaceuticals, to ensure adequate protection of the staff and the environment.

f) To ensure that an adequate system of radiation monitoring is implemented, in all departments in which ionizing radiation is employed, in collaboration with the appropriate national and/or provincial health authorities.

g) To ensure that adequate records are maintained of all matters pertaining to radiation hazards and radiation doses received by Institute and Hospital personnel and, where applicable, patients and other persons; and to ensure that cases of over-exposure or unwarranted hazard are investigated and that remedial action is taken.

h) To ensure that Institute and Hospital personnel are properly instructed in matters of radiation hazards and radiation safety.

i) To ensure that plans are prepared and suitable equipment made available to deal with accidents and emergencies involving an actual or potential radiation hazard. Such emergencies include incidents occurring within or outside the Institute and Hospital which result in the arrival at the Institute or Hospital of persons who are contaminated with radioactive materials and/or have received excessive doses of radiation.

j) To prepare, and to revise from time to time, a "Radiation Safety Manual" which incorporates the rules, recommendations, instructions, data and other information required for the implementation of these Terms of Reference.

k) To supervise and direct the activities of the Radiation Safety Officer in implementing the various measures laid down in these Terms of Reference.

l) To report to the Director of the MNI and to the Associate Executive Director of the MNH/MUHC as well as to the Canadian Nuclear Safety Commission whenever a situation arises, involving an actual or potential radiation hazard, such that the effective control of the hazard lies outside the authority vested in the Radiation Safety Committee and/or the Radiation Safety Officer.

2.2 Radiation Safety Officer (RSO)

The RSO is responsible for implementing the Terms of Reference of the Committee set out in 2.1.2 above. In particular, the duties of the RSO shall include:

2.2.1 Assessment of the status of radiation safety measures undertaken in all rooms, laboratories, wards and other locations where radiation sources (including patients containing radioactive sources) are housed and/or used.

2.2.2 Providing or organizing such services as may be required for radiation safety and for compliance with federal, provincial and local laws and recommendations, where these services cannot be provided internally by individual departments or laboratories. Examples of these services are:

a) Instruction and training of employees in the safe handling of radiation sources.

b) Calibration, certification and maintenance of radiation monitoring equipment.

c) Carrying out radiation surveys, including environmental surveys, personnel monitoring (additional to that provided by the national monitoring service) and surveys relating to particular equipment or procedures.

d) Survey of the collection and disposal of radioactive waste.

e) Planning for, and supervision of, emergency procedures and special decontamination operations.

f) Maintenance of records relating to all aspects of radiation safety, including personnel exposure records, radiation survey records and licensing documents.

g) Participation in the planning of new installations or procedures involving radiation sources.

h) Co-operation with federal, provincial and local authorities in all matters relating to radiation safety.

2.2.3 Reporting to the Radiation Safety Committee regularly and whenever any unusual or emergency situation arises or has recently been dealt with. In particular, the RSO shall

perform **internal inspections** of all radioisotope facilities that operate under a CNSC license issued to the MNH/I and present the results of such inspections to the RSC**.**

2.3 Responsible Radiation User (RRU)

A **Responsible Radiation User**, sometimes also called Permit Holder, is a person who is officially designated, for licensing or other purposes, as the individual responsible for the procurement and use of specified radiation sources. A **Responsible Radiation User** is normally the director of a department, division or laboratory. As such, he is ultimately responsible for providing adequate facilities, equipment, supervision and instruction needed by his staff to enable radiation sources to be handled safely and in compliance with the requirements of this manual. Frequently, the day-to-day responsibilities for some of these matters are delegated to a **Departmental Radiation Supervisor (DRS)** (e.g., chief technician, see 2.4 below). Whether the responsibility is exercised directly or is delegated, the list of duties related to radiation safety is as given in 2.4 below.

2.3.1 Internal Permit Application

Responsible Radiation Users performing in-vitro and animal laboratory studies that are covered by a Consolidated License issued by the CNSC to the MNH/I must obtain an internal permit (see section 6.2 of the RSM). The application form requires information such as:

- name and position of Responsible Radiation User
- name and position of Departmental Radiation Supervisor
- names of radiation badge users
- list of radioisotopes to be used and means and areas of storage
- radioisotope reception procedures
- intended use
- list of sealed radioisotopes in use, with their respective activities (per manipulation; per year)
- available radiation monitoring equipment
- waste disposal procedure
- proof of radiation safety training for staff, willingness to attend RS course

2.4 Departmental Radiation Supervisor (DRS)

The Departmental Radiation Supervisor (DRS) is a person who works full-time in a given area, laboratory or other circumscribed location, such that he/she is able to provide day-to-day supervision of the work of employees in matters of radiation safety. The DRS derives his/her authority from the Head of the Department, Director of the Laboratory or other Responsible Radiation User as defined in 2.3. In particular, the DRS is responsible for:

a) Maintaining (in co-operation with the RSO) an up-to-date list of rooms in which radiation sources are installed, stored, handled, used or applied.

b) Maintaining a day-to-day inventory of radiation sources in the form of radiation-emitting equipment and/or radioactive sources (open or sealed) received, used or disposed of (relative to each project).

c) Ensuring that all persons handling radiation sources receive adequate instruction in the safety aspects of such handling. For that purpose, the DRS will direct new radiation users (fellows, post-docs, technicians, students) to the RSO who will assure that these individuals will attend the appropriate training sessions (see Chapter 14: Education and Training of Personnel for more information on this topic).

d) Allowing only authorized persons to enter areas that are specified as restricted for reasons of radiation safety.

e) Ensuring that personnel wear assigned radiation monitors throughout the working day and that such monitors:

i) are not left in close proximity to radiation sources when not being worn; and

ii) are handed in promptly at the end of each monitoring period or before the user commences a period of prolonged absence.

f) Posting warning labels and signs as required by current laws and safety codes.

g) Establishing, and ensuring observation of, appropriate working procedures (in co-operation with the RSO) to guarantee compliance with applicable laws and safety codes.

h) Ensuring that radioactive waste is disposed of in strict accordance with the rules described in this manual.

i) Notifying the RSO when any female Nuclear Energy Worker under his/her supervision, or any such worker about to come under his/her supervision, is known to be pregnant.

j) Supplying the RSO with all the information needed for licensing purposes and/or issuing of the internal permit.

k) Ensuring that, when required, personnel make themselves available for bioassay procedures such as thyroid monitoring and that adequate records of the results of such procedures are maintained.

l) Monitoring the work area for radioactive contamination at least weekly and recording the results in a log book.

2.5 Individual "Radiation Workers" (RW)

An individual **RW**, for the purpose of this manual, is an individual that handles radioactive substances under the direction of a DRS or, by extension, of a RRU as defined earlier in this chapter. RSC of the MNH/I requests that every **RW** abides by the rules set out in paragraphs a) to c) below:

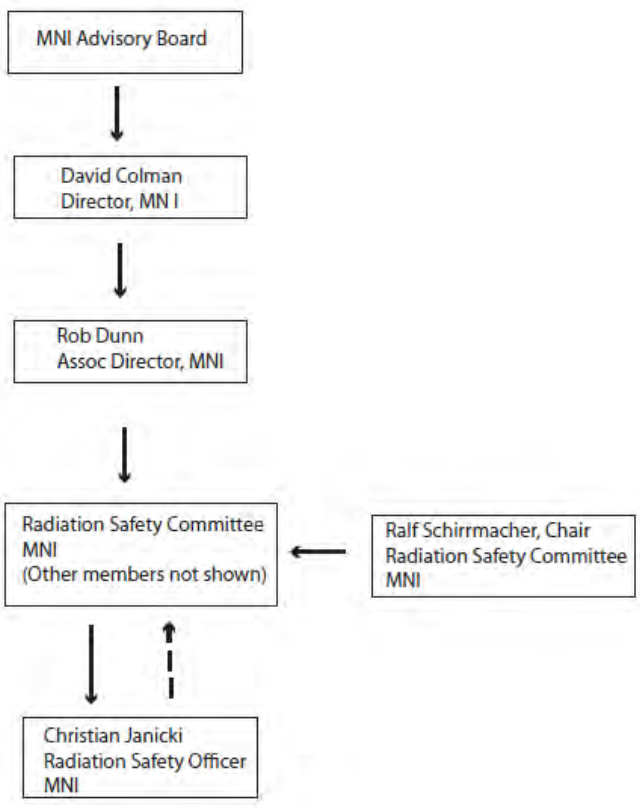
a) Every individual **RW** who acquires, installs, stores, handles or applies radiation sources is responsible for working in such a way that he/she does not endanger either himself/herself or his/her colleagues and that he/she complies with the procedures and rules laid down by the Departmental Radiation Supervisor and/or listed in the applicable sections of this manual.

b) An **RW** is responsible for any radiation monitor (e.g., TLD monitor) assigned to him/her and must carry it on his/her person throughout the working day. He/she must not lend or assign his/her personal monitor to anyone else, nor leave the monitor outside working hours in such a location that it could be exposed to radiation.

c) An **RW** should read and understand the relevant sections of this manual and other regulatory documents applicable to his/her type of work. (The sections concerned will be

assigned by the Responsible Radiation User, in consultation with the RSO). To this end the worker may request a copy of this manual and a copy of the relevant Safety Code (edited by the CNSC or Quebec provincial authorities) for his/her personal use, if he/she so desires.

2.6 Diagram of the administration



A diagram of the administration (Direction, RSO/NSRD and RSC) is illustrated here.

3. Licensing and Authorization

3.1 General Principles

3.1.1. The Canadian Nuclear Safety Commission (CNSC) licenses the possession and use of radiation sources in Canadian hospitals and research institutions. Licensed activities include the following categories:

a) Unsealed radioisotopes and radiopharmaceuticals used for diagnosis or therapy on human subjects, whether in a Department of Nuclear Medicine or elsewhere.

b) Unsealed radioisotopes used for investigations and research not involving human subjects (in-vitro or animal laboratory studies).

c) Unsealed radioisotopes used for investigations and research involving human subjects (human research studies such as positron emission tomography investigations on human volunteers).

d) Sealed radioisotopes used in therapy, including sources intended for implantation and sources housed in teletherapy (e.g. cobalt) units.

e) Sealed radioisotopes permanently housed in instruments and equipment. This category includes sealed isotopic sources provided for instrument calibration, for diagnostic purposes (e.g. bone mineralization scanners) and for neutron activation analysis.

f) particle accelerators that are capable of giving rise to high-energy ionizing particles, either as the useful product (e.g. a beam of high energy electrons) or as a by-product (e.g. stray neutrons). In practice this means that all medical accelerators (linear accelerators, betatrons, cyclotrons) are licensable.

g) Processing and shipping of radioisotopes produced by a particle accelerator (e.g., production and transfer, resp. sale, of 18F-FDG produced by a medical cyclotron).

3.1.2 The list in 4.1.1 excludes all radiographic and fluoroscopic equipment in the Diagnostic X-ray Department (at present under the jurisdiction of the “Laboratoire de Santé Publique du Québec). It is probable, but not certain, that x-ray machines will become licensable in the future under the Quebec Public Health Protection Act. In that event, this section of the manual will be revised.

3.2 MNI/H Licenses for Nuclear Substances and Devices

3.2.1. There are four CNSC licenses for Nuclear Substances and Radiation Devices at the MNI/H. These are:

1- Consolidated use of nuclear substances (815)

2- Human research (875)

3- Diagnostic Nuclear Medicine (862)

4- Basic servicing (822)

Class II licenses (cyclotron facilities) are:

1 – PET Cyclotron facility operation (516)

2 – Class II prescribed equipment servicing (566)

The licenses are valid for the period indicated on the Licenses (fixed by the CNSC) unless otherwise suspended, amended, revoked or replaced. Each license includes a list of conditions that shall be met by the licensee and subject to inspections or audits by the Commission on a periodic basis. Also, the licensee shall submit to the CNSC a written annual compliance report in a form acceptable to the Commission. Failure to comply with the all the regulations might result in the licenses being suspended or revoked by the Commission.

3.2.2. Copies of the MNI/H licenses are accessible to all workers and include all the conditions that need to be met for compliance with the CNSC regulations. These conditions serve as a basis for the policies developed in this manual for the consolidated use of nuclear substances. This manual also includes policies that meet or exceed the conditions for all licenses listed above. Copies of the licenses are available from the RSO at the MNI/H.

3.2.3. As part of the licensing conditions, some of the MNI/H's obligations are:

a) to train workers to carry on the licensed activities in accordance with the Act, the regulations made under the Act and the license;

b) to take all reasonable precautions to protect the environment and the health and safety of persons and to maintain security;

c) to take all reasonable precautions to control the release of radioactive nuclear substances within the sites of the licensed activities;

d) to notify the Commission of the person (name, position title) who is responsible for the management and control of the licensed activities, and notify the Commission of any changes in the above information within 15 days;

e) For any site where licensed activities (consolidated use of nuclear substances) are to be conducted for more than 90 days, notify the Commission in writing of the site within 7 days of starting to conduct the activities at the site. Also, notify the Commission in writing of the site within 7 days of the discontinuance of licensed activities at any site.

3.3 Use of radioactive sources on human volunteers

3.3.1. Administration of nuclear substances to human subjects is strictly prohibited under the consolidated license as indicated in Condition 1 of the license.

3.3.2. Nuclear substances can only be administered to human subjects under the human research or diagnostic nuclear medicine licenses.

3.3.3. The guidelines published by the CNSC in the document *Guidelines for research on human subjects using radionuclides* (GMA-5), Dec 93, should be followed.

3.3.4. An applicant for a license for the use of radiation sources in human subjects has to satisfy the following conditions, as required by the CNSC:

a) he/she is a qualified and registered Nuclear Medicine specialist of the province of Quebec;

b) he/she is qualified and experienced in the handling of radioisotopes and radiation sources;

c) the quantities of radioisotopes to be purchased, stored and handled at any one time do not exceed the safe limits for the type of laboratory and facilities available;

d) the procedure (protocol) and administered radioactivity per subject (human volunteer) are approved by the Research Ethics Board (REB);

e) adequate instrumentation for measurement and monitoring of radiation is available.

3.3.5. The RSO at the MNI/H, in consultation with the applicant, will assure the complete and timely processing and/or renewal of any specific license application to be submitted to the CNSC.

3.4 Records, Reports and Licensing issues

3.4.1 The licensee must keep the following documentation related to the utilization of nuclear substance at the MNI/H. Records to be kept are:

- List of all authorized users and their records of training
- List of all locations where nuclear substances are being used or stored
- The name, quantity, form and the location of any nuclear substance being used
- The manner in which it is used
- Name of each worker who uses or handles a nuclear substance
- List of all sealed sources or radiation devices (manufacturer, model, serial numbers)
- Records of any measurements and surveys done by the RSO (area monitoring, contamination monitoring)
- Any records of transfer, receipt, disposal or abandonment of nuclear substances
- The record of all inspections, measurements and tests done by the RSO
- The contamination monitoring records done by the laboratory workers
- Personal dose monitoring records (TLD results from NDS, thyroid monitoring)

With the exceptions below, all documents must be kept for a period ending 3 years after the expiry of the license. Contamination monitoring records must be kept for a period ending 1 year after the expiry of the license. Records of training for authorized users must be kept for a period ending 3 years after the termination of employment of the worker.

No documents shall be disposed unless the RSO has notified the CNSC of the date of disposal and of the nature of the records of at least 90 days before the date of disposal.

3.4.2 The RSO must maintain a list of all licenses issued by the CNSC related to the utilization of nuclear substances and radiation devices (NSRD)

3.4.3 The RSO is responsible for submitting annually an Annual Compliance Report as requested by the CNSC at a date fixed by the Commission (as indicated on the licenses).

3.4.4 The RSO is responsible for the administration of the CNSC licenses at the MNI/H. This includes the any requests for amendments and renewal of licenses.

4. Regulatory Dose Limits

The Canadian Nuclear Safety Commission (CNSC), under the Radiation Protection Regulations (RPR SOR/2000-203), defines limits on the effective dose received by and committed to a person, and limits on the equivalent dose received by and committed to an organ or tissue.

4.1 Effective and Equivalent dose limits

4.1.1 Effective dose limits

The effective dose limits are given in the table below.

"Every licensee shall ensure that the effective dose received by and committed to a person described in column 1 of an item of the table to this subsection (below), during the period set out in column 2 of that item, does not exceed the effective dose set out in column 3 of that item". (RPR 13.1)

	Column 1	Column 2	Column 3
Item	Person	Period	Effective Dose (mSv)
1.	Nuclear energy worker, including a pregnant nuclear energy worker	(*a*) One-year dosimetry period	50
		(*b*) Five-year dosimetry period	100
2.	Pregnant nuclear energy worker	Balance of the pregnancy	4
3.	A person who is not a nuclear energy worker	One calendar year	1

4.1.2 Equivalent dose limits

The equivalent dose limits are given in the table below.

"Every licensee shall ensure that the equivalent dose received by and committed to an organ or tissue set out in column 1 of an item of the table to this subsection (below), or a person described

in column 2 of that item, during the period set out in column 3 of that item, does not exceed the effective dose set out in column 4 of that item." (RPR 14.1)

Item	Column 1 Organ or Tissue	Column 2 Person	Column 3 Period	Column 4 Equivalent Dose (mSv)
1.	Lens of an eye	(*a*) Nuclear energy worker	One-year dosimetry period	150
		(*b*) Any other person	One calendar year	15
2.	Skin	(a) Nuclear energy worker	One-year dosimetry period	500
		(*b*) Any other person	One calendar year	50
3.	Hands and feet	(*a*) Nuclear energy worker	One-year dosimetry period	500
		(*b*) Any other person	One calendar year	50

Some of the definitions used in the tables above in the next section.

4.1.3 Definitions

Nuclear Energy Worker (NEW): A person who is required in the course of the person's business or occupation in connection with a nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public.

One year dosimetry period: a period of one calendar year beginning on January 1 and every period of one calendar year thereafter.

Five year dosimetry period: a period of five calendar years beginning on January 1 and every period of five calendar years thereafter.

Balance of pregnancy: period of time from the moment the licensee is informed in writing of the pregnancy, until the end of pregnancy.

4.2 Nuclear energy workers

As defined in the Radiation Protection Regulations under the *Nuclear Safety and Control Act* (SOR/2000-203), a "Nuclear energy worker" means:

“a person who is required, in the course of the person’s business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there are reasonable probability that the person may receive a dose of radiation that is greater then the prescribed limit for the general public.”

This refers to the maximum permissible dose for a member of the public of 1 mSv per year. Regulatory dose limits are discussed in details in section 3 of this manual. The RSO designates any person to be considered as a "Nuclear energy worker". These workers may include:

- Nuclear Medicine technologists and physicians
- Electronic technicians working in Nuclear Medicine
- Medical Physicists
- Isotope Laboratory workers
- The radiation safety officer and assistants

A person designated as a NEW at the MNI/H must sign the Nuclear Energy Worker Designation form in Appendix 2.

At the MNI/H, employees working in radioisotope laboratories are usually not classified as Nuclear energy workers, but the RSO reserves the right to change this classification if deemed necessary.

4.3 Pregnant Nuclear Energy Workers

4.3.1 Every nuclear energy worker who becomes aware that she is pregnant shall immediately inform the licensee in writing.

4.3.2 On being informed by a nuclear energy worker that she is pregnant, the licensee shall, in order to comply with the legal limits shown in the preceding table (4 mSv for the balance of the

pregnancy), make any accommodation that will not occasion costs or business inconvenience constituting undue hardship to the licensee.

4.4 General Public

The dose limit for non-Nuclear Energy Workers and members of the public is 1mSv in one calendar year. As stressed in paragraph 1.2, the ALARA principle applies and every effort must be made to reduce the actual doses received by non-Nuclear Energy Workers to as low a level as possible. This applies to any situation in the hospital in which non-Nuclear Energy Workers or members of public, including patients, may be exposed to radiation from devices or substances regulated by the CNSC or to radioactive contamination, in circumstances such that the individual concerned derives no personal benefit from the exposure.

4.5 Action Levels

4.5.1. The doses listed in the tables above (section 4.1) are maximum permissible doses or MPD (also referred to as dose limits). They are in no sense "dose allotments" which can and should be used up. On the contrary, the guiding principle of all radiation work is: the dose should be as low as is reasonably achievable, economic and social factors being taken into account. This is called the "ALARA" principle and is central to all radiation safety.

4.5.2. In order to retain control over the radiation safety program, and in accordance with the CNSC Radiation Protection Regulations (sec. 6, SOR/2000-203), action levels are defined. “Action level” means a specific dose or other parameter that, if reached, may indicate a loss of control of part of licensee’s radiation protection program and triggers a requirement for specific action to be taken. Action levels are discussed in detail in the CNSC document G-228 *Developing and using Action Levels.*

4.5.3. Action levels for Nuclear Energy Workers at the MNI/H:

Any Nuclear Energy Worker (NEW) whose annual dose exceeds *one-tenth of the yearly MPD* is subject to investigation by the RSO. This corresponds to an effective dose of 5 mSv over a one-year dosimetry period and is within the limits usually met by most Nuclear Medicine technologists. However, for some rare cases, this limit might be exceeded. Once this level has been reached for any NEW, and if there are no clear reasons to explain the unusual exposure report (e.g. unusual workload with nuclear medicine patients, emergency situations, …) the RSO shall take the following actions:

- Conduct an investigation to establish the cause for reaching the action level
- Identify and take action to restore the effectiveness of the radiation safety program
- Notify the Commission within the period specified in the license if applicable

Note: For cyclotron production workers, the extremity doses are known to exceed *one-tenth of the yearly MPD* (i.e 50 mSv/y) in some cases. For these workers, action consists in close monitoring of their TLD reading for extremity on a continuous basis during the year (monthly TLD service). Results of the latest TLD report are extrapolated to the 12 month period and additional actions are taken if the extrapolated data is likely to exceed the 500 mSv annual limit. Action may consist in suspending the activities, diminution of the workload, revision of work handling procedures or additional shielding as recommended by the RSO.

4.5.4. Action levels for laboratory workers (not Nuclear Energy Workers) at the MNI/H:

For laboratory workers that are not declared NEW but that are monitored for radiation exposure with personal dosimeters (e.g. TLD's), the action level is set *one-half the yearly MPD*. This corresponds to an effective dose of 0.5 mSv over a one-year dosimetry period. For laboratory workers making extensive use of radionuclides and for which good laboratory practices and ALARA principle does not suffice to keep their effective dose below 1 mSv over a one-year period, the RSO will consider declaring them as NEW after examining every other alternatives.

4.5.5. The table below summarizes the action levels at the MNI/H.

TYPE OF WORKER	ACTION LEVELS
Nuclear Energy Workers (NEW)	5 mSv (total body) 15 mSv (lens of an eye) 50 mSv (skin) 50 mSv (hand and feet)
Radioisotope workers (only if not declared NEW)	0.5 mSv (total body) 7.5 mSv (lens of an eye) 25 mSv (skin) 25 mSv (hand and feet)

Note: Special condition apply for extremity dose of cyclotron production workers (see above).

4.5.6. Other Action levels include decontamination criteria, which are discussed in details in Chapter 6 of this manual. Any room, enclosure, device or work area where surface contamination criteria are reached or exceeded must be decontaminated immediately until the contamination level is reduced below the acceptable limits.

5. Radiation Monitoring

5.1 General Principles

Monitoring of dose and dose rates and measurement of contamination levels are essential components of any radiation protection program. Such monitoring includes:

- Area monitoring, i.e. measurement of radiation dose rate at various points in areas, rooms or enclosures where unsealed nuclear substances are used or stored;

- Technique monitoring, i.e. measurement of radiation dose rate received by specific individuals and/or at specific locations, during particular procedures involving radiation sources.

- Personnel monitoring, i.e. measurement of the total dose received by individual radiation users over a period of time.

- Bioassays to determine the level of radioisotopes ingested or inhaled by the user. These techniques are used when an incident occurs and incorporation of radioisotopes is suspected. Bioassays are also performed on a routine basis for users of volatile high toxicity isotopes such as I-125 and I-131 (Thyroid monitoring).

- Medical surveillance of users: pre-placement health assessment and special tests in case of overexposure.

- Leak testing of sealed sources;

- Contamination monitoring, i.e. measurement of contamination levels in all areas, rooms or enclosures where unsealed nuclear substances are used or stored.

Contamination monitoring will be discussed in detail in the next chapter.

5.2 Area and technique monitoring

5.2.1. The responsibility for these types of monitoring rests with the RSO. It is the RSO's responsibility to carry out, either directly or by delegation, whatever surveys and measurements needed to ensure that room and equipment shielding are adequate to ensure a proper standard of radiation safety.

5.2.2 Permit holders, heads of department, departmental radiation supervisors and individual Nuclear Energy Workers have the duty to collaborate with the RSO in this task, and in particular, inform the RSO of any situation or procedure which warrants special investigation. In addition, permit holders and/or heads of department and departmental radiation supervisors have the responsibility of carrying out whatever recommendations are made as a result of such investigations.

5.2.3. No person shall use a radiation survey meter that has not been calibrated within the 12 months preceding its use. The requirements for gamma radiation survey meter calibration are described in the CNSC document CNSC *Regulatory Expectations for Calibration of Survey Meters*. All survey meters at the MNI/H must be calibrated as per CNSC requirements.

5.2.4. All radiation readings performed during a radiation survey must be recorded. Information recorded should include the date and location of the measurement and the name, model and serial number of the measuring instrument.

5.2.5. na

5.3 Personnel monitoring

5.3.1 Nuclear Energy Workers are subject to routine, continuous monitoring of the radiation dose received from external sources by means of a Thermoluminescent Dosimeter (TLD) badge. TLDs are the official dosimeters for dose measurements of external radiation and must be worn by Nuclear Energy Workers.

5.3.2 TLD exposure monitoring is also performed on regular workers handling radioactive substances or devices as per CNSC regulations (e.g., workers handling more than 50MBq of P-32 need to wear an extremity TLD monitor) or if there is a real possibility of exposure to radioactivity either directly or indirectly.

5.3.3 The dosimeter service at the MNI/H is provided by the National Dosimeter Service (NDS) of the Radiation Protection Bureau (RPB) of Health Canada, which is a service of the Federal Ministry of Health and Welfare. (The RPB is a provider of dosimetry services recognized by the CNSC).

5.3.4 Depending on the service requested by the various radiation users, TLDs are provided periodically by the RPB at intervals of ½ , 1 or 3 months. The distribution within the MNI/H is

undertaken in each department or laboratory by the Departmental Radiation Supervisor or delegate.

5.3.5 At the end of a dosimetry period, the holders should be collected in each department or laboratory by the DRS or his delegate who:

a) returns the exposed plaques to the NDS, with a list of the users;

b) distributes the holders containing the plaques to the individual workers;

c) enrolls pregnant workers on the special NDS semi-monthly monitoring program;

d) provides extremity badges to workers as needed.

5.3.6 The exposed TLD chips are measured by the NDS and a report of the radiation dose received by each worker is sent to the RSO. The RSO conducts a review of the report and any unusually high value (greater than the action levels set in section 4.4.5) is subject to investigation. The RSO retains the original of the report. For NEW (e.g. Nuclear Medicine technologists) and radiation workers (e.g. X-Ray technologists), the RSO sends a copy of the report to the departmental radiation supervisor who is responsible for displaying it on a departmental bulletin board (or otherwise conveying the results to the individuals concerned).

5.3.7 All radiation dose records, including measurements of external irradiation and estimated doses resulting from internal irradiation if applicable) are maintained at the radiation safety office and are available to the worker and his supervisor.

5.3.8 Responsibility of individual workers

The individual worker is responsible for:

a) taking good care of the monitor at all times;

b) wearing the monitor at all times during working hours. The monitor may be worn where the source is nearest, either at waist or at chest height. Where a lead apron or other protective clothing is worn, the monitor should be carried under the apron since its job is to record the radiation reaching the body, not the radiation reaching the apron;

c) guarding the monitor as a personal monitor, issued to a named individual. In no circumstances may a monitor be loaned to another person or otherwise used to record doses received by more than one individual or used for any other purpose than personal monitoring;

d) taking care that the monitor does not accidently drop onto the floor or onto any place (e.g. a radiographic table) where it might accidently become exposed to a direct radiation beam;

e) taking care that the monitor is not accidently splashed or otherwise contaminated by a radioactive solution;

f) taking care that, outside working hours, the monitor is left in a safe place which is well away from any radiation source and from any source of intense heat including a radiator.

5.3.9 Additional information on the proper handling, wearing and storage of whole body and extremity dosimeters can be found in the CNSC INFO-0688 poster in Appendix 3.

5.3.10 Limitations of TLD monitoring

Personnel monitoring of the type described in the previous two sections is a satisfactory general indicator of whole-body dose due to external X or gamma-radiation. However, the system has some important limitations:

a) it does not record the additional dose received by the hands, limbs or face in some procedures; workers using large quantities of high energy beta emitters should therefore wear wrist or ring dosimeters to measure extremity doses,

b) it does not record exposure arising form internal ingestion of radioactive materials;

c) it does not record doses due to low energy beta rays such as those from tritium, carbon-14 and sulphur-35;

d) the 3-monthly cycle is too long for some individuals whose work carries a higher-than-average risk of exposure.

5.4 Thyroid Monitoring

5.4.1. Monitoring of internal radioactivity requires the setting up of special sensitive equipment for external counting of gamma radiation from radioisotopes deposited in the body. This equipment for both I-125 or I-131 is available to the RSO.

5.4.2. na

5.4.3. Every person shall undergo thyroid screening within five days who:

(a) uses in a 24-hour period a quantity of Iodine-125 or Iodine-131 exceeding;
(i) 2 MBq in an open room;
(ii) 200 MBq in a fume hood;
(iii) 20 000 MBq in a glove box;
(iv) any other quantity in other containment approved in writing by the Commission or a person authorized by the Commission; or

(b) is involved in a spill of greater than 2 MBq of Iodine-125 or Iodine-131;or
(c)on whom Iodine-125 or Iodine-131 external contamination is detected.

5.4.4. The RSO must be contacted as early as possible after use to make arrangements for thyroid monitoring. Failing repeatedly to report within five days for the mandatory screening (see conditions above) could result in the suspension or revocation of the Internal Permit to perform work with I-125 or I-131 (see Enforcement policy in section 6.14).

5.4.5. Screening for internal Iodine-125 and Iodine-131 is performed using a direct measurement of the thyroid with a thyroid uptake probe that can detect 1 kBq of I-125 or I-131. The RSO provides thyroid-monitoring service for laboratory workers. At the time of writing this manual, laboratory workers working under the Consolidated license manipulate only I-125. Nuclear Medicine technologists are occasionally exposed to I-131 volatiles, and for those workers, the monitoring is performed in the Nuclear Medicine department.

5.4.6. The RSO at the MNH (through the MUHC) participates regularly to the Thyroid Intercomparison program from the Canadian National Calibration Reference Center for In-Vivo Monitoring and has demonstrated a Minimum Detectable Activity (MDA) for the counter and probe being used (LUDLUM 2200 + NaI gamma probe) of less than 100 Bq typically for I-125. Details about the MDA calculation for I-125 are presented in Appendix 4.

5.4.7. If thyroid screening detects more than 10 kBq of Iodine-125 or Iodine-131 in the thyroid, the RSO shall immediately make a preliminary report to the CNSC and have bioassay performed within 24h by a person licensed by the CNSC to provide internal dosimetry services.

5.5 Medical surveillance

The guidelines in this section are based on the document published by the CNSC in "Revised Guidelines for the Medical Surveillance of Nuclear energy workers", (GMA 8), May 93.

5.5.1 Pre-placement Health Assessment

Medical examinations for Nuclear energy workers need be no different than those for other workers performing similar tasks in the absence of radiation.
Every Nuclear energy worker should undergo a pre-placement medical assessment for the following purposes:

- to determine fitness for the "specific work" for which the worker is to be employed;
- to provide a baseline reference for use when considering subsequent changes which may be related to the worker's occupation or which may influence fitness for work;
- to provide data which may be useful for later epidemiological studies.

The medical conditions which a physician must look for are those which would impair the ability to wear protective clothing, the ability to hear alarms and to assess radiation hazards and the ability to work with specific tools and equipment.

5.5.2 Periodic Health Assessment
Occupational exposure to ionizing radiation below regulatory limits does not constitute a reason for performing periodic health assessments and termination of work health assessment.

5.5.3 Special assessments and tests may be warranted in cases of radiation overexposures exceeding regulatory limits. In these cases, the CNSC document"Guidelines for counselling after occupational overexposure to ionizing radiation" (GMA-6) will be followed.

5.6 Leak testing of sealed sources

5.6.1. The requirements for Leak testing are described in the CNSC document "*CNSC Regulatory Expectations for Leak Testing of Sealed Sources*". All leak tests at the MNI/H must be done as per CNSC requirements.

5.6.2. Leak tests are performed on all sealed sources containing more than 50 MBq of radioactive material at the following frequencies.

i) For each sealed source continuously in storage - every 24 months;
ii) For each sealed source which is incorporated in a device - every 12 months;
iii) For a sealed source or shielding that is to be used after being stored for 12 or more consecutive months – immediately before using it;
iv) For any other sealed source over 50 MBq – every six months.

5.6.3. Leak testing is also arranged immediately following an incident that could have damaged a sealed source.

5.6.4. If leakage is detected in excess of 200 Bq, the sealed source or the radiation device shall be taken out of service and the RSO contacted immediately. The RSO will take the necessary steps to control the spread of contamination and will immediately notify the CNSC.

6.0 Radiation Safety in Radioisotope Laboratories

6.1 General Principles

At the MNI/H, unsealed nuclear substances are used and stored in many clinical or research laboratories. Users of radioisotopes in research and investigations not involving human subjects are not issued with individual licenses by the CNSC but are included in a consolidated MNI/H license covering all applications of this kind.

6.2 Internal Permits for radioisotope laboratories

6.2.1. Internal Permits to work with nuclear substances in laboratories are issued by the RSO and delivered to Permit Holders who are responsible for the use of nuclear substances in their laboratories.

6.2.2. Each Permit Holder must hold a valid Internal Permit issued by the RSO. Each Internal Permit contains specified conditions of approval, compliance with which is mandatory.

6.2.3. To apply for an Internal Permit, the form "Application for Radioisotope Internal Permit" should be obtained from the RSO, completed in full, and returned to the RSO (see Appendix 5). The Application is then reviewed by the RSO and conditions of approval are formulated if necessary.

6.2.4. A copy of the approved Internal Permit is sent to the applicant and another copy is retained by the RSO. The Permit holder shall forward to the RSO any changes in the information provided with the internal permit application, especially in the personnel using isotopes in his group.

6.3 Classification of Laboratories and Posting

6.3.1 Any laboratory or area in which unsealed radioisotopes are stored, handled or used should be classified in accordance with CNSC Regulatory Document GD-52 entitled “Design Guide for Nuclear Substance Laboratories and Nuclear medicine Rooms”. This document details the facilities (including surface finishes, bench tops, fume hoods, air movement, floors, sinks and drains) required in laboratories designated as "Basic", "Intermediate" or “High” level.

6.3.2 The classification of laboratories is determined by the Annual Limit of Intake (ALI) for specific isotopes manipulated. The ALI means "the activity, in Bq, of a radionuclide that will deliver an effective dose of 20 mSv during the 50-year period after the radionuclide is taken into the body of a person 18 years old or older or during the period beginning at intake and ending at the age of 70 after it is taken into the body of a person less than 18 years old." (RPR SOR/2000-203, 12.(1)). ALI values for isotopes used in laboratories are given in Appendix 8.

6.3.3. For radioisotope laboratory classification, condition 5 of the Consolidated license (see Appendix 1) indicates that:

The licensee shall classify each room, area or enclosure where more than one exemption quantity of an unsealed nuclear substances is used at a single time as:

(a) **basic-level** if the quantity does not exceed 5 ALI

(b) **intermediate-level** if the quantity does not exceed 50 ALI

(c) **high-level** if the quantity does not exceed 500 ALI; or

(d) **special purpose** if approved in writing by the Commission or a person authorized by the Commission

6.3.4. Except for the basic-level classification, the licensee shall not use unsealed nuclear substances in these rooms, areas or enclosures without written approval of the Commission or a person authorized by the Commission.

6.3.5. The responsible manager and/or permit holder must ensure that every point of access to an area, room or enclosure where there is more than 100 EQ of radioactive materials or where the radiation dose rate might exceed 25 μSv/h are labeled with a radiation warning sign that bears the trefoil symbol and the words "RAYONNEMENT-DANGER-RADIATION". Additional information on the warning sign could include the room number, usage and the CNSC classification of item 6.3.3. The RSO will identify the rooms that require the warning signs and will provide the posting material to the permit holder as necessary.

6.3.6. Based on the above classification, in laboratories falling into the basic-level category, the "Basic Level" poster (INFO-0728-1) shall be posted and kept posted in a readily visible area. For areas in the intermediate-level category, the "Intermediate Level" poster (INFO-0728-2) applies and for high-level areas, the "High Level" poster (INFO-0728-3).

6.3.7. A 24-h emergency contact (name and phone number) and the room identification number must be displayed clearly on the CNSC room classification posters.

6.3.8. In radioisotope laboratories, the CNSC poster *Spill Procedures* (INFO-0743 in Appendix 3) should be posted and kept posted in a readily visible area. The poster shall include the name and telephone numbers of the RSO and the person in charge of the laboratory (Permit Holder or DRS).

6.3.9. In radioisotope laboratories, the CNSC poster *Guidelines for Handling Packages Containing Nuclear Substances* (INFO-0744 in Appendix 3) should be posted and kept posted in a readily visible area.

6.3.10. In radioisotope laboratories, the current Internal Permit with the names of the Permit Holder and phone number, room numbers, isotopes and authorized activities must be posted and kept posted in a readily visible area.

6.3.11. Any construction or modification of an existing laboratory must be submitted to the RSO for approval. For basic-level laboratories, the RSO will review the modifications according to the GD-52 document to ensure the modifications that are proposed are in agreement with the CNSC regulations and the conditions of the license.

6.3.12. Any construction or modification of Intermediate and High-level laboratories must, in addition to the condition above, be approved in writing by the CNSC.

6.3.13. A 24-hour emergency contact number must be posted in all storage rooms or areas. If more than 100 EQ of a nuclear substance is stored in a room, a radiation warning symbol with the wording RADIATION-DANGER-RAYONNEMENT must be posted at every point of access to the room or area.

6.3.14. A 24hour emergency contact number must be posted on or near all radiation devices (e.g. LSC). If the radiation device contains more than 100 EQ of a nuclear substance, a radiation warning symbol with the wording RADIATION-DANGER-RAYONNEMENT must be posted at every point of access to the room or area where the device is located.

6.3.15. No person shall post or keep posted a sign that indicates the presence of radiation or a nuclear substance (trefoil symbol) at a place where the radiation or nuclear substance is not present. For example, the trefoil symbol should not be posted on calculators, pipettes, rulers,

pencils or any other items used in the laboratories unless these items are contaminated with radioactivity and cannot be decontaminated immediately.

6.3.16. The trefoil symbol on any item must be defaced before this item is disposed into the regular garbage, radioactive waste container or any other waste containers (e.g. chemical, biohazard).

6.4 Project Approval for the use of more than 10, 000 EQ

6.4.1 For projects requiring the use of more than 10,000 EQ of a nuclear at a single time, a special authorization shall be obtained from the CNSC before starting any work.

6.4.2 na.

6.5 Purchases of Radioisotopes

6.5.1 All purchases of radioactive materials for Consolidated activities must be approved by the RSO prior to processing. The RSO maintains a record of all radioactive materials purchased at the MNI/H.

6.5.2 The MNI/H research laboratories should submit their purchase requests to their respective purchasing department. The purchasing department shall not proceed with the order before approval by the RSO.

6.5.3. The activity of each type of radioisotope that can be purchased, stored and used by the individual Permit Holder or DRS is limited by the possession limit indicated on the internal permit and, for the institution as a whole, by the maximum quantities (possession limits) specified on the CNSC license.

6.5.4. na.

6.5.5 The RSO will only approve imports of nuclear substances and prescribed equipments that are authorized under the conditions of the CNSC consolidated license (see Appendix 1). The total quantity of sealed and unsealed nuclear substances shall not exceed the limits set in Section IV of the consolidated license.

6.5.6 Condition 16 of the consolidated license (see Appendix A.) also limits the quantities of tritium, plutonium, thorium and uranium that can be purchased at the MNI/H. The RSO will only approved purchases that are below the limits set in condition 16 of the consolidated license.

6.6 Receiving of radioactive packages

6.6.1 Radioactive packages are class 7 dangerous goods and are delivered to the MNI/H according to the CNSC and the Transportation of Dangerous Goods regulations. The consignor (e.g. Fedex personnel) must trained and be able to produce a certificate of training in the Transport of Dangerous Goods (TDG, class 7) if asked by an inspector.

6.6.2. Transport by the consignor is completed when the package enters the building and arrive at the MNI/H receiving area where it is unloaded and transferred to the MNI/H personnel (consignee). A TDG certificate is not required to move or store temporarily the package inside the building.

6.6.2 Most class 7 packages delivered to laboratories are either excepted packages (no special marking) or Type A packages with Category I, II or III marking. Detailed information about the package labeling is given on the CNSC poster *Guidelines for Handling Packages Containing Nuclear Substances* (INFO-0744) in Appendix 3 of this manual.

6.6.3. Upon arrival at a loading dock of the MNI/H, if the package is visibly damaged in any way, receiving personnel must contact immediately the laboratory personnel (indicated on the packing slip) or the radiation protection service (RSO) through MNI/H Locating (ext.-53333) for assistance. Depending on the severity of the damage, the laboratory or RSO personnel will determine if the package should be accepted or returned to sender.

6.6.4 Excepted packages can be moved from the receiving area to the laboratory like any other ordinary packages. Type A, Category I packages (see INFO-0744, Appendix 3) can be moved also to the laboratories safely but preferably using a cart that will be pushed with arms extended (avoid unnecessary body contact). For Type A category II and III, receiving personnel should store the package in a safe area (locked area if unattended) and call the laboratory personnel or the RSO for further instruction. In most cases, category II and III packages will be picked-up directly by the laboratory personnel.

6.6.5 New packages containing radioactive material delivered to the laboratory must be examined by the Permit Holder or an authorized person following the guidelines set in CNSC

document INFO-0744 "Guidelines for handling packages containing nuclear substances" (see Appendix 3).

6.6.6. Under no circumstances should it be possible for radioactive materials to be delivered and left unattended, without the knowledge of an authorized person.

6.6.7 Most packages received at the MNI/H in the laboratories will be "excepted packages". These packages have no radiation warning symbols on it and can be opened like ordinary packages. However, for Type A packages, the person who handles the package must have a valid TDG certificate of training to open it. If a laboratory receives a Type A package and no one possess a valid TDG certificate, you should notify the RSO immediately before opening the package. The RSO can provide a short training session and issue a TDG certificate for handling of Type A packages if necessary.

6.7 Storage of Radioactive Material

6.7.1 All radioactive material must be kept in appropriately shielded containers that are marked with appropriate radiation warning signs and carry a label indicating the name of the radioisotope (e.g., 32P), its activity (e.g., 50MBq) and date of the assay (determination) of the activity (e.g., May 20th, 2003).

6.7.2 All containers must be stored in a safe area, compartment or facility, which must be lockable. Freezers located in hallways, if permitted by the Fire Marshal, that contain radioactive materials must be lockable and kept locked at all times. Only authorized/trained personnel should have access to the nuclear substances.

6.7.3 The storage area also has to be identified with the proper radiation warning sign (symbol in black or magenta on a yellow background and the words **"**RAYONNEMENT – DANGER – RADIATION**"** a) if more than 100 exemption quantities of a radioactive substance are stored in the area, or b) if there is a reasonable probability that a person in the area will be exposed to an effective dose rate greater than 25µSv/hr.

6.7.4 The storage location or facility must have sufficient shielding to reduce the radiation level to no more than 25µSv/hr in areas accessible to Nuclear Energy Workers only, and to a level not exceeding 2.5µSv/hr in areas accessible to other persons.

6.7.5 It is strictly forbidden to store or to consume any kind of food or beverage in an area where radioactive material is used or stored.

6.7.6 The storage facility must be of fireproof construction.

6.7.7 Gaseous radioactive materials should be kept in a fume-hood provided with adequate ventilation.

6.8 Handling of unsealed radioisotopes in laboratories

6.8.1 In any laboratory where both radioactive and non-radioactive work are carried out, a separate area must be set aside and clearly designated as the "radioactive area". (Do not use the official yellow and black, or yellow and magenta, radiation warning labels for outlining this area, rather use another type of warning label, e.g., a black radiation warning sign on white background).

6.8.2. The Permit Holder or DRS must ensure any container or device that contains a radioactive nuclear substance are labeled with:

- a radiation warning sign symbol (trefoil symbol in Appendix 3)
- the words “RAYONNEMENT-DANGER-RADIATION”;
- the name, quantity, date of measurement and form of the nuclear substance in the container or device;

This directive does not apply if in respect to a container or device

- that is used to hold a radioactive substance for current or immediate use and is under the continuous direct observation of the user;
- in which the quantity of radioactive nuclear substances is less or equal to the exemption quantity (EQ);

6.8.3 Smoking, eating, drinking and storage of food or drink are prohibited in any area used for storage, handling or use of radioactive material.

6.8.4 Pipetting of radioactive solutions must not be carried out by mouth.

6.8.5 Procedures involving radioactive materials should be carried out in trays or on benches lined with disposable absorbent material. Secondary containments should be used for all radioactive liquids.

6.8.6 Procedures that might produce airborne contamination should be carried out in a fume hood. In any case, some method of containment should be adopted.

6.8.7 Procedures involving dry radioactive powdered materials should be carried out in a glove box.

6.8.8 Laboratories must be kept locked when not in use.

6.8.9 When hand or clothing contamination is possible, protective gloves and clothing must be worn.

6.8.10 After handling unsealed radioactive materials and before leaving the laboratory the operator should monitor his/her hands for contamination.

6.8.11 Equipment, tools and utensils used for work with radioactive materials should not be used for other purposes and should be surveyed for contamination prior to removal from the laboratory.

6.9 Contamination Monitoring

6.9.1. Contamination monitoring must be done in all areas where unsealed nuclear substances are used. However, contamination monitoring is not required when working only with the short-lived (PET) radioisotopes (C-11, N-13, O-15 and F-18).

6.9.2. Radioactive contamination should be measured directly or indirectly. Direct measurement means the use of portable radiation detection instruments to detect both fixed and removable contamination. Direct measurement may be used when background radiation levels are negligible compared to license criteria. Indirect measurement only detects removable contamination by means of wipe tests.

6.9.3. Monitoring for removable contamination should be done immediately following radioactive work or at least weekly. Surfaces that exceed the criteria stated in the license conditions must be decontaminated. Records of the monitoring and the decontamination results should be kept in a logbook and are subject to regular inspections by the RSO or the CNSC.

6.9.4 In laboratories where radioisotopes are manipulated regularly and frequently (at least once a week), contamination monitoring should be done at least weekly and the results recorded in the

logbook. For laboratories that remain inactive for several weeks (as is often the case for small laboratories), contamination monitoring should be done shortly after each manipulation and the results recorded in the logbook. A statement such as "No nuclear substances used this week" should be filed in the logbook when appropriate, indicating that no contamination monitoring is necessary for that period.

6.9.5 Portable monitors, suitable for measuring contamination arising from the type of radionuclide stored or used in that laboratory must be available. Guidelines on instrument selection and measurement methods for contamination monitoring (e.g. direct method using portable meter; indirect method using wipe tests) are detailed in Appendix 7. The RSO can assist in selecting the instrument that is suitable for each laboratory.

6.9.6 Before monitoring for contamination, portable instruments should be given operational checks as specified by the manufacturer (battery check, response check etc.) and the background radiation level should be measured.

6.9.7 Non portable instruments for counting wipes, such as liquid scintillation counters, well-crystal type gamma counters, should be routinely serviced according to the manufacturer's instructions. A copy of service information should be kept with the contamination monitoring records. A blank and a standard should be counted and recorded with each set of wipes.

6.9.8 The locations that are to be monitored should be numbered on a plan of the radioisotope work area or described on a detailed list. These locations should include working surfaces (benches, countertops, fume hoods, etc.), storage areas, and non-working surfaces (floors, instruments, refrigerator, sink, bench, etc.) as appropriate. Several random locations should also be monitored. Too rigid a set of locations may overlook problem areas.

6.9.9 Contamination monitoring records must be kept for 1 year after the expiry of the license and must include:

(a) date of measurement
(b) make an model of the instrument
(c) monitoring locations
(d) contamination monitoring results in Bq/cm2 (before and after decontamination)
(e) results of operational checks and background measurements for portable instruments.
(f) blank and standard measurement results for non-portable instruments.

6.9.10 The CNSC has grouped radionuclides into three classes – "Class A", "Class B", or "Class C"- on the basis of common radiological characteristics. A classification table for common radioisotopes is given in Appendix 8.

6.9.11 The contamination criteria set by the CNSC are as follows:

The non-fixed contamination in all areas, rooms or enclosures where unsealed nuclear substances are used or stored (controlled areas), averaged over an area not exceeding 100 cm^2, shall not exceed:

(i) 3 Bq/cm^2 for all Class A radionuclides;
(ii) 30 Bq/cm^2 for all Class B radionuclides;
(iii) 300 Bq/cm^2 for all Class C radionuclides.

The non-fixed contamination in all other areas (public areas), averaged over an area not exceeding 100 cm^2, shall not exceed:

(i) 0.3 Bq/cm^2 for all Class A radionuclides;
(ii) 3 Bq/cm^2 for all Class B radionuclides;
(iii) 30 Bq/cm^2 for all Class C radionuclides.

Surface contamination limits are given in Appendix 8 for common radioisotopes along with additional data.

6.9.12 For any contamination level above the legal limits defined in item 6.9.11, decontamination procedure shall be undertaken. However, these legal limits are by no means limits below which decontamination procedure should be stopped. On the contrary, efforts should be made to reduce the contamination to levels As Low as Reasonably Achievable (ALARA). While in principle there is no contamination level at which the ALARA concept should not be applied, the RSO considers that further decontamination effort is not normally required if the non-fixed contamination averaged over an area not exceeding 100 cm^2 does not exceed:

(i) 0.05 Bq/cm^2 for all Class A radionuclides;
(ii) 0.5 Bq/cm^2 for all Class B radionuclides;
(iii) 0.5 Bq/cm^2 for all Class C radionuclides.

6.10 Decommissioning of radioisotope laboratories

All items, rooms or equipment which have been used for work with unsealed radioactive materials must be properly decommissioned prior to their use in non radioactive circumstances or prior to their disposal in a non radioactive waste stream as appropriate.

6.10.1 Before any radioisotope facility is decommissioned, a radiation survey shall be performed and appropriate actions shall be taken to remove any areas of contamination where the count rate is above background. The form "Decommissioning Report" (see Appendix 9 for a copy of the form) has to be completed by the Permit Holder or DRS and sent to the RSO.

6.10.2 Items, equipment, fume hoods, enclosures or rooms used for unsealed radioactive material should be monitored for contamination using: a) Direct monitoring using a contamination meter or b) Indirect monitoring, using the wipe test method. Both contamination-monitoring methods are discussed in details in Appendix 7.

6.10.3 The non-fixed contamination, averaged over an area nor exceeding 100 cm2, shall not exceed the levels indicated in section 6 of this manual.

6.10.4 All nuclear substances and radiation devices must be transferred or disposed in accordance with the conditions of the license.

6.10.5 All radiation warning sign must be removed or defaced.

6.10.6 Once decommissioning is complete, the RSO will usually arrange for a final inspection to be conducted, and will arrange for notification of the permit holder that decommissioning is complete.

6.10.7 Note that CNSC approval is required for decommissioning where fixed contamination in an area remains. This would be as detected by the contamination monitoring instrument which is appropriate for detection of the radioisotope. The RSO will only approve the areas as decommissioned upon receipt of approval to do so from the CNSC.

6.10.8 Records of the monitoring results must be maintained on record for three years. Records should be maintained by the individual requesting the decommissioning and the RSO.

6.11 Using radioisotopes with animals

In laboratories where nuclear substances are administered to animals, the internal permit holder and radioisotope users should follow these guidelines in addition to all other procedures for the safe handling of radioisotopes in laboratories.

6.11.1. A request to amend an Internal Radioisotope Permit must be made to the RSO. Where appropriate, the animal center will be listed on the internal permit as a use room.

6.11.2. Animal caretakers personnel should be authorized by the RSO, or work directly under the supervision of authorized person.

6.11.3. Waste products from animals and cages that contains levels of radioactivity above background level must be kept for decay before disposal through the regular waste system. The RSO must be consulted prior to disposal of any radioactive waste through the municipal garbage system or municipal sewer to verify if the levels are below the limits set in the conditions of our licenses.

6.11.4. Whenever possible, radioactive animal carcasses and excreta must be stored in a freezer and kept for decay before being disposed through the normal route for biomedical or biohazard materials at the MNI/H. The RSO will determine if the carcasses are radioactive or not by monitoring them with the appropriate instruments. If storage and decay is not possible, radioactive animal carcasses must be placed in a double plastic bag and frozen before disposal through the McGill Waste management center. A radioactive label must be tagged around the plastic bag indicating the internal permit number, isotope, estimated activity and date.

6.11.5. After cleaning the cages, contamination monitoring should be performed to ensure there is no contamination. If any contamination is found, the cage must be cleaned and tested again until there is no contamination present.

6.12. Inventory control and Disposal of Radioactive Waste

This section details the process by which radionuclides are inventoried and secured at the MNI/H. It is essential to ensure the cost effective disposal of radioactive waste and also to meet regulatory and safety requirements that the amount of radioactivity present in the laboratory, the amounts used and the amounts transferred to radioactive waste are properly recorded and are accurate at all times.

General Procedure:

The procedure for ordering, tracking radioisotopes and waste disposal can be summarized as follows.

At the MNI/H, any purchasing of radioisotope must be approved first by the RSO (a radioisotope order form like the one in Appendix 10 should be filled and send to the RSO for approval who will fax it to McGill purchasing department unless agreed otherwise). As soon as the package is received, information about the product must be entered in the MyLAB tracking system by the laboratory personel. Waste containers must also be created in MyLAB and the system will generate a tracking number for each of them. Every Permit Holder who has a MyLAb account must use his own waste containers even in laboratories that are shared (no sharing of waste containers).

Empty waste containers are available in room B045 at the MNI/H. Keys to access that room are available from the security front desk (you will have to sign in a log book). In the room, radioactive wastes are stored inside a metallic cage which is locked by a combination lock (contact the RSO to get the combination). Waste containers that are full must be closed following MyLAB procedure and returned to room 045B for pick-up by McGill Waste management. A wipe test must be done on every container before taking them back to room 045B and records must be kept in the laboratory.

Detailed Procedures:

6.12.1 All radioactive material in the radioisotope laboratory and in radioactive waste must be recorded using the McGill University electronic Radioisotope Tracking System (MyLAB). Details about the MyLAB system are given in Appendix 10. Comprehensive notes and visual slideshow on how to use the MyLAB for tracking and disposal of nuclear substances are available for download at http://www.mcgill.ca/eso/training/presentations/#1. When deemed necessary by the RSO (e.g. intermediate and high level laboratories), the running log form in Appendix 10 should also be filled and kept in a log book in the laboratory.

6.12.2. The inventory of each radioisotope (or multiple radioisotopes), by-products, and radioactive waste must be printed out and posted on the outside of the storage unit at least weekly so that it is easy to identify the radioactive products in the storage unit.

6.12.3. Waste generated from the use of radioactive material should be disposed of as radioactive waste via the McGill University Waste Management Program.

6.12.4. The Waste Management Program supplies laboratories with different types of containers. The user must properly complete identification tags, attached to each container, prior to pick up by the Waste Management Program technician. In addition, users are required to segregate radioactive waste in separate containers, according to three categories. They include:

- Liquid Scintillation Vials (LSV) are disposed in the 5 gallon (20 litre) steel pails and then the letters "LSV" are written on the container lid. There is no need to empty each liquid scintillation vial. It is recommended to place a plastic bag inside to line the pails and to attach the completed identification tag.

- Solid Waste is disposed in the 5 gallon (20 litre) steel pails or cardboard boxes or in smaller containers like 4 litre white plastic or 1 litre clear plastic containers. Only solid and dry materials should be placed in these containers and the completed identification tag must be attached.

- Liquid waste other than LSV must be emptied in 4 liter white plastic or 1 liter clear plastic containers and identified with the completed identification tag.

- Animal Carcasses must be put in a double plastic bag, tied and tagged with completed identification label. Carcasses must be frozen at the time of collection.

6.12.5. As soon as the containers become full, they should be moved to the central collection area located in the basement of the MNI, room B045 and disposed of following MyLAB rules.

Keys to the radioactive waste storage room B045 are available upon signing a book, at the front desk (security, main floor) 24 hours a day, 7 days a week. Also, a log book in room B045 must be filled with the container information that was delivered which includes the container ID number, permit number or name of responsible person.

6.12.6. New, empty radioactive waste containers (1L and 4L plastic container, 20L metal pail or cardboard box) can be collected from the above locations as necessary.

6.12.7. The McGill Waste management System will only collect waste that are properly prepared prior to collection. Waste that are not in the specific containers indicated above, or waste that do not have an identification number, activity and date info will not be collected.

6.12.8 Lead waste may be recycled in a non-radioactive waste route once it has been monitored directly using an appropriate contamination monitor and once wipe tests have been taken and verified free of contamination. All radioactive warning labels must be removed.

6.12.9. Plastic pigs may be disposed of in the municipal garbage once they have been monitored directly using an appropriate contamination monitor and once wipe tests have been taken and verified free of contamination. All radioactive warning labels must be removed.

6.12.10. The MNI/H is licensed only to dispose small quantities of radioactive waste across the entire institution to the municipal sewer or garbage routes. Additionally, MNI/H must keep a detailed inventory of all unsealed nuclear substances disposed of to the sewer. For this reason any proposals to dispose of radioactive material to the municipal sewer or garbage must be referred to the RSO for prior approval.

6.12.11. Approval by the RSO must be obtained prior to the use of this disposal route, and inventory records must be maintained on all disposals and made available upon request.

6.12.12. All labels indicating the presence of radioactive material must be defaced prior to disposal in the municipal garbage.

6.12.13 Before waste containers are transferred to McGill waste management, a wipe test must be performed and records kept in a log book in the laboratory. Records must be available during an inspection. Contamination monitoring must indicate a level of contamination of less than 0.4 Bq/cm2. After the wipe test indicate the acceptable limit is satisfied, the container is marked with a visible letter “W” circled with a black marker (if the circled W sign is not visible, McGill waste management will not pick-up the container).

6.13 Housekeeping and technical services

6.13.1. In rooms or enclosures where nuclear substances are used or stores, housekeeping personnel must:

- Always lock door when leaving the room;
- Never eat or drink in the room;
- Never touch a container or device labeled with the radiation warning sign;
- Never proceed with the cleaning of an intermediate or high-level laboratory without the supervision of an authorized user;

6.13.2. Technical staff that must proceed with the repair of ventilation system, construction work, plumbing, etc… must inform the RSO in order to have a contamination monitoring done before authorizing any work.

6.13.3. In case of an emergency (e.g. flooding, fire, …), work can be initiated without approval from the RSO. The RSO will monitor the room after the work is completed to verify the presence of any contamination.

6.14 Enforcement of the Radiation Protection Program in laboratories

6.14.1. It is the responsibilities of the Internal Permit Holder to ensure the radioisotope workers working under their supervision follow the procedures and working practices set forth in this manual to comply with the CNSC regulations and license conditions.

6.14.2. The RSO can provide support on any issues related to the safe use and handling, transport or disposal of nuclear substances in the laboratories.

6.14.3. The RSO will inspect laboratories to verify compliance with the licensing conditions on a regular basis. As a guideline, High level laboratories should be inspected monthly, intermediate-level labs quarterly and basic labs annually. A monitoring checklist for internal compliance is provided in Appendix 11.

6.14.4. Offences will be categorized as minor or major. A major offence would result from violations that pose immediate risk or danger to safety, health, release to the environment of reportable quantities, doses of substantial amount to staff, or place the CNSC Consolidated Radioisotope License in jeopardy. Examples of a major offence include:

- contamination above license criteria;
- inadequate monitoring program;
- use or storage of food or drink in the laboratory;
- inadequate training of new staff;
- non-participation in required bioassay programs;
- inadequate and/or unsafe work and storage areas for radioisotopes; and
- inadequate and/or unsafe storage areas for radiation waste.

A minor offence would be an infraction that poses no immediate risk or threat to health, safety, the environment or the license. Examples of a minor offence would include:

- inadequate signage;
- inadequate posting (internal radioisotope permit, CNSC posters);

- inadequate inventory records;
- inappropriate use of warning labels; and
- inappropriate segregation and/or identification of radiation waste for disposal or decay.

6.14.5. Offenses are usually corrected after the RSO has informed the workers about the situation and made recommendations. However, in some circumstances where the situation is repeated, each major or minor infraction may be reported as a "strike" and additional strikes may be recorded if the problem has not been corrected after repeated warnings. The strike policy is as follows:

- Strike 1: Repeated infractions are observed and recorded by the RSO. The RSO will inform the Permit Holder by way of copy of inspection report or memorandum and sets a deadline for correcting the situation.

- Strike 2: Permit Holder has not replied within due date or the same infraction is observed during a follow up inspection. The RSO revises the deadlines and informs the Permit Holder that sanctions might follow if the situation is not corrected.

- Strike 3: The RSO will schedule a follow up inspection and to observe if the same infraction is still not corrected after the compliance deadline. If the same infraction is noted again, the RSO will notify the associate Dean and the Chair of the Radiation Safety Committee and will advise the Permit Holder of sanctions. Sanction options include suspension of purchasing privileges, suspension of Internal Permit or confiscation of radioactive materials by the RSO.

6.15 Packaging and Transport of Nuclear Substances

6.15.1 Any transfer of nuclear substance from the MNI/H (consignor) to another licensee taking possession of the radioactive material (consignee) must be done in accordance with the Transport Canada Regulation on the Transport of Dangerous Goods (TDG) and the CNSC packaging and Transport of Nuclear Substances Regulations. A detailed procedure for the packaging and transport of Class 7 (radioactive) packages is described in Appendix 3A of the manual.

6.15.2 Anyone who transport or offers for transport a package containing a nuclear substance must be trained in the transport of dangerous goods (TDG class 7) and have a valid TDG

certificate issued by his employer. It is strictly forbidden for anyone to transport or ship nuclear substance outside any building without TDG training and a valid TDG class 7 certificate.

6.15.3 Anyone worker who needs to package, transport or ship a nuclear substance outside their building must contact the radiation safety office for prior approval. The RSO will provide assistance for all issues related to the packaging and transport of the nuclear substance to a new consignee. Any transport papers must be signed by the RSP staff or a qualified person (with valid TDG class 7 certificate) before any package containing a nuclear substance is offered for transport outside the building.

7.0 Radiation Safety in Nuclear Medicine & Human Research

7.1. General Procedures in Nuclear Medicine & Human Research

7.1.1. The administration of nuclear substances to humans at the MNI/H is authorized under the Diagnostic Nuclear Medicine and the Human Research CNSC licenses.

7.1.2. na

7.1.3. It is the responsibility of the chief technologist to ensure that routine work conducted in the Nuclear Medicine department is performed in accordance with the procedures described in this manual.

7.1.4. Radiation exposures can occur in the nuclear medicine department during the handling of radiopharmaceuticals or through patient contact. All staff should minimize radiation exposure to unshielded radioactive materials as far as possible through the use of time, distance and shielding practices as described in the safe work procedures. Staff should also ensure that they wear the appropriate dosimetry at all times to record radiation exposures.

7.1.5 PET procedures are carried out with radio-nuclides such as: 15O (T1/2=124s), 13N (T1/2=10 min), 11C (T1/2= 20 min), and 18F (T1/2=110 min). These radio-nuclides are positron emitters and are produced by the medical cyclotron located in the basement of the MNH/I.

7.1.6 Some of the PET tracers such as the radioactive gases 15O -CO or 15O-CO2 produced at the radiochemistry laboratory in the cyclotron facility are sent directly to the PET unit by means of a system of stainless steel tubes, so that the exposure to personnel is minimal, and the gases are utilized for imaging (inhalation studies) without delay .

7.1.7 Some non-volatile compounds are also produced at the cyclotron facility. These ready-to-inject compounds, such as 18F-FDG, are shipped to the PET scanning suite via a pneumatic system.

7.1.8 For handling of Tc-99m, special contamination monitoring and waste disposal forms are available in Appendix 12 to facilitate the mandatory bookkeeping (see below).

7.2 Classification of laboratories and Posting

7.2.1. All rooms where radioactive materials are stored, used or manipulated must be labeled with a radiation warning sign. The sign must be conspicuously placed allowing it to be immediately noticed by anyone entering the room or enclosure. The sign must bear the trefoil symbol, room number and usage and the CNSC classification.

7.2.2. A room is classified as “nuclear medicine” for the use of unsealed nuclear substances if the nuclear substance is prepared for or administered to a person. In these rooms, the “Nuclear Medicine” poster (INFO-0728-4/Rev.1) must be displayed (see Appendix 3).

7.2.3 The “hot lab” in nuclear medicine is classified as a “nuclear medicine” room in accordance with the definition given in item 7.2.2. The old classification as an "intermediate laboratory" is obsolete.

7.2.4. A 24-h emergency contact (name and phone number) and the room identification number must be displayed clearly on the CNSC room classification posters.

7.2.5. In radioisotope laboratories, the CNSC poster *Spill Procedures* (INFO-0743 in Appendix 3) must be posted and kept posted in a readily visible area. The poster shall include the name and telephone numbers of the RSO and the person in charge of Nuclear Medicine (manager or chief technician).

7.2.6. In the “hot lab” where radioactive packages are received and handled, the CNSC poster *Guidelines for Handling Packages Containing Nuclear Substances* (INFO-0744 in Appendix 3) must be posted and kept posted in a readily visible area.

7.2.7. Any construction or modification of an existing Nuclear Medicine must be submitted to the RSO for approval. The RSO will review the modifications following guidelines such as those given in CNSC document GD-52 “Guide for Nuclear Substances Laboratories and Nuclear Medicine Rooms” or use equivalent dose analysis to ensure the modifications that are proposed are in agreement with the CNSC regulations and the conditions of the license.

7.2.8. New nuclear medicine rooms or any changes to existing rooms must be approved by the CNSC.

7.3 Purchases, Reception and Storage of Nuclear Substances

7.3.1. The chief technologist or delegate orders radioactive material from the manufacturer.

7.3.2. The nuclear medicine technologist records the date, time, name and activity information on the inventory sheet for each lot number as radiopharmaceuticals are administered to patients. The inventory records must always accurately reflect the nuclear substances in storage or use at any given time

7.3.3. Unit doses are stored in their transport cases prior to use and are the container are returned to their transport cases following use. The case must be returned as an *excepted package*. The procedure is as follows:

1. Perform a visual inspection of the case.
2. Make sure that the case is empty. Remove all syringes and vials.
3. Complete an entry on your Shipping Log indicating date, case number, signature, contamination and radiation monitoring level.
4. Perform wipe test on the case, especially handles and latches. The result must be < 0.4 Bq/cm2.
5. Perform radiation monitoring on the case in contact with the dose rate meter. Radiation (dose) level may not exceed 0.5 mR/h or 5 uSv/h at any surface.
6. In case of non- compliance with the Exempted Packages conditions, leave and keep the case open in the nuclear medicine department until compliance can be achieved.
7. If the levels are below the limits, turn warning labels around so the “UN 2910” side is visible.
8. Leave the package in a safe and secure area.

7.3.4. na

7.3.5. Sealed sources for nuclear medicine department are ordered through and received by the chief technologist or delegate. The chief technologist informs the RSO of any new source acquisition in order to maintain an accurate inventory of sealed sources.

7.3.6 When there is no authorized individual is present in the room or the storage area that contains radioisotopes must be locked to prevent unauthorized access.

7.4 Handling of unsealed radioisotopes in Nuclear Medicine Rooms

7.4.1 Disposable gloves should be worn during the injection of radioactive material.

7.4.2 Syringes used for the injection of radioactive material must be shielded. This rule may be relaxed only in exceptional circumstances.

7.4.3 A lead apron should be worn whenever possible during long manipulations when high activity Tc-99 solutions are handled.

7.4.4 Distance between the technologist and the patient shall be maximized during imaging procedures.

7.4.5 Procedures involving a radioactive gas must be carried out in such a way, that no dispersal of the gas is possible into the immediate environment.

7.4.6 Radioactive substances shall be transported in a container that would prevent spillage. A cart shall always be used when material is transported in public areas.

7.4.7 Radioactive material in storage shall be shielded appropriately such that radiation levels shall not exceed 2.5 μSv per hour in public areas.

7.4.8 Used syringes or needles containing residues of radioactive material should be separated from other radioactive waste.

7.4.9 Waste shall be segregated according to the different half-lives. All waste shall be kept for 10 half-lives and checked with appropriate monitor prior to disposal.

7.4.10 Preparation and administration areas shall be surveyed every day.

7.4.11 All areas where radiopharmaceuticals are used or stored shall be surveyed for removable contamination every seven days and filed into a log book.

7.5 Thyroid Monitoring

7.5.1 Nuclear Medicine staff who manipulates Iodine-125 or Iodine-131 must follow the procedure for thyroid monitoring described in Section 5.5 of this manual.

7.5.2. The Nuclear Medicine department at the MNI/H (through the MUHC) participates regularly to the Thyroid Intercomparison program from the Canadian National Calibration Reference Center for In-Vivo Monitoring and has demonstrated a Minimum Detectable Activity (MDA) for the counter and probe being used of less than 1 kBq for I-131 as required by the licensing conditions. Details about the MDA calculation for I-131 are presented in Appendix 4.

7.6 Contamination Monitoring and Leak tests

7.6.1. The Assistant-chief technologist is required to ensure that monitoring for radioactive contamination is conducted in the department.

7.6.2. Contamination monitoring in Nuclear Medicine is done according to the same guidelines as described in Section 6.9 of this manual.

7.6.3 The assistant-chief technologist arranges for routine leak tests of sealed sources in accordance the procedure *Leak Testing* in section 5.5 of this manual.

7.7 Decommissioning of Nuclear Medicine Rooms

7.7.1 Decommissioning of Nuclear Medicine rooms is the responsibility of the Nuclear medicine department. The RSO will approve the decommissioning after the decommissioning procedure is completed.

7.7.1 Items, equipment, fume hoods, enclosures or rooms used for unsealed radioactive material should be monitored for contamination using: a) Direct monitoring using a contamination meter or b) Indirect monitoring, using the wipe test method. Both contamination-monitoring methods are discussed in details in Appendix 7.

7.7.2 The non-fixed contamination, averaged over an area nor exceeding 100 cm2, shall not exceed the levels indicated in section 6 of this manual.

7.7.3 All nuclear substances and radiation devices must be transferred or disposed in accordance with the conditions of the license.

7.7.4 All radiation warning sign must be removed or defaced.

7.7.5 Once the decommissioning procedure is complete, the RSO will usually arrange for a final inspection to be conducted, and will notify the Nuclear Medicine manager when decommissioning is confirmed.

7.7.6 When a patient is administered radiopharmaceutical on a treadmill, the treadmill room should be temporarily posted with the radiation warning symbol. Also, the treadmill room should be decommissioned after the Nuclear Medicine procedure is completed.

7.7.7 CNSC approval is required for decommissioning where fixed contamination in an area remains. This would be as detected by the contamination monitoring instrument which is appropriate for detection of the radioisotope. The RSO will only approve the areas as decommissioned upon receipt of approval to do so from the CNSC.

7.7.7 Records of the monitoring results must be maintained on record for one year after the expiry of the license.

7.8 Inventory control and Disposal of Radioactive Waste

7.8.1 Nuclear medicine radioactive waste is segregated according to its half-life. Sharps are placed into hospital issued biohazard containers. A radioactive label is attached as well as a label indicating its contents.

7.8.2 Once the container is full, it is closed, dated, and decayed. Before disposal, the container is monitored using a contamination monitoring instrument. Radioactive labels are removed and the container is placed out for biohazard waste collection.

7.8.3 Labels are maintained in the waste removal inventory book with the date of disposal, the contamination monitor reading and the initials of the person who conducted the monitoring and authorized the waste for disposal.

7.8.4 Miscellaneous waste is collected in specially marked radioactive material waste containers. This is also monitored prior to disposal as previously described.

7.8.5 Waste can be disposed though the municipal garbage system when the reading using the contamination meter is comparable to the background radiation.

8. Radiation Safety for the Gammacell 1000 Irradiator

8.1 General Principles

8.1.1 The gammacell irradiator used at the MNI/H is operated under the CNSC Consolidated license.

8.1.2 The Gammacell 1000 Irradiator is a self shielded type irradiator. It is composed of a high activity Cs-137 radioactive source , the main biological shield, a movable rotor which houses the irradiation chamber and the control mechanisms. The radioactive source is installed in the source holder at the factory and is mechanically locked and welded in place in such a manner as to prevent any inadvertent or accidental removal.

8.1.3 According to the Gammacell 1000 Specifications Sheet by AECL (June 1979), the average dose rate at 5 cm from the surface of the shield will not exceed 5 μSv/h. This will be reduced to 0.05 μSv/h at 50 cm ($1/r^2$ law). Asssuming the maximum workload for any worker using the irradiator is ~50h/y, the effective dose received by any worker is less than 250 μSv/y at 5 cm and less than 2.5 μSv/y at 50 cm from the irradiator, and thus does not exceed the limit for public over a one-year period.

8.1.4 The sealed source information for the gammacell must be entered and tracked in the CNSC Self-Serve Tracking System (SSTS). Authorization code to access the SSTS was provided to the RSO by the CNSC through the Transport Licensing and Strategic Support Division (classified as confidential information).

8.2 Safety Procedures

8.2.1 The RSO is responsible for ensuring that all staff and activities using the gammacell work in accordance with this procedure.

8.2.2. A list of authorised users of the gammacell is required to be maintained. All authorized users:

- have attended a radiation safety training session approved by the RSO;
- have been properly instructed in its safe use and in the contents of this procedure.

8.2.3. The key to access the room in which the gammacell is located must be kept in the designated storage location when the gammacell is not in use by an authorised user.

8.2.4. Upon completion of use of the gammacell, the user must replace the key in the designated storage location.

8.2.5. The gammacell must not be left unattended at any time with the door unlocked.

8.2.6. Any requirements to modify the gammacell must be notified to the RSO prior to the modification being made. The Manager of the RSO will only approve any such modifications in conjunction with approval from the CNSC as per license conditions.

8.2.7. Any plans to modify the location where the gammacell is stored (including displacing the machine, changing locks, and renovating the room) must be approved by the RSO prior to commencing work.

8.2.8. Any incident or malfunction involving the Gammacell Irradiator must be reported immediately to the RSO in order that an appropriate response and follow up actions may be taken.

8.2.9. A leak test on the Cs-137 sealed source shall be done annually by a person or a company approved by the CNSC.

8.2.10 The RSO must be contacted for any purchasing, replacement, reception or transfer of the gammacell irradiator or source. The RSO will be responsible for any transport issues indicated above for which TDG training is mandatory.

8.3 Procedure to Access the Gammacell Irradiator at the MNI/H

Step 1- User authorization

a) The gammacell is classified as a high risk area at the MNI. Access to the device is under strict control. To get access to the gammacell at the MNI, you must first obtain authorization from the radiation safety office. In order to get authorized, any person must forward the following information to the attention of the radiation safety office:

1- Full name and date of birth;
2- Name of the supervisor (PI) with location and phone number;
3- Certificate of training in radiation safety;
4- The person's personal history, composed of their educational achievement, professional qualifications, employment history and character references;
5- A letter from the PI assessing the trustworthiness and reliability of all persons who require authorized access;

b) Future requirements will include a record emanating from the Canadian Police Information Center or from a police service servicing the locality where the facility is located, showing the result of a criminal record checks on the person. Additional security measures to be implemented will be announced in due time.

c) Once the approval process is completed, the name of the person will be added to the list of authorized users and forwarded to the MUHC security department.

Step 2- Access to the gammacell

Full instruction set to access the gammacell is **prescribed information** and will be forwarded to the PI through internal mail service only (no email or fax) after user authorization step 1 is completed.

9. Safety Guidelines for Diagnostic Radiology

This section has been removed. Please refer to the MUHC Radiation Safety Manual (NSRD)

http://www.medphys.mcgill.ca/clinical/MUHC_RSM_NSRD_V162a.pdf

10. Procedures for Minimizing Dose to Patients

This section has been removed. Please refer to the MUHC Radiation Safety Manual (NSRD)

http://www.medphys.mcgill.ca/clinical/MUHC_RSM_NSRD_V162a.pdf

11. Radiation Safety in the Wards

This section has been removed. Please refer to the MUHC Radiation Safety Manual (NSRD)

http://www.medphys.mcgill.ca/clinical/MUHC_RSM_NSRD_V162a.pdf

12. Procedures for the MNI/MNH Medical Cyclotron Facility

12.1 Introduction

The MNI/H Medical Cyclotron produces radioactive nuclides for use in medical and biological research and nuclear medicine procedures by bombarding target materials with accelerated protons and deuterons. The nuclides so produced are transferred to the radiochemistry laboratory or "hot lab" for processing. Because of the nature of the operations, radiation as well as non-radiation hazards exist.

Depending upon the particle energy and the material irradiated, high fluxes of secondary neutrons and gamma radiation may be produced. Residual radioactivity may be induced in the cyclotron structure and components and in the structural materials surrounding the cyclotron. The radioactive nuclides created by the irradiation of target materials and transferred to the hot lab may also emit significant amounts of radiation. During the handling and processing of irradiated target materials, radioactive gases or particulates may escape into the atmosphere. In addition to these radiological health hazards, non-radiation hazards such as mechanical, electrical, toxic chemical, fire and explosion hazards exist.

The purpose of these safety procedures is to ensure maximum safety to all personnel in and around the Medical Cyclotron Facility. They are intended to establish and maintain correct methods of operational safety and to familiarize personnel with the potential hazards. The procedures reflect the policies and recommendations of the MNI/H Radiation Safety Committee and conform to the Regulations and Requirements of the Government of Quebec and the Canadian Nuclear Safety Commission.

The procedures and instructions that are unique to the activities and operations in the facility are covered in detail in this chapter. General safety practices pertaining to the initiation and maintenance of records, radioactive material labeling, waste disposal, and non-radiation hazards are discussed only briefly.

12.2 Description of Cyclotron Facility

The Cyclone 18/9, designed by IBA (Ion Beam Applications, Belgium, at the time of acquisition marketed through Siemens Medical Systems), is a negative ion machine that

produces protons of 18MeV and deuterons of 9MeV at maximum beam currents of approximately 100µA and 40µA respectively. There are two radially mounted ion sources, one for each particle. Acceleration is achieved by using a magnet and RF system. It has eight external beam ports with dedicated chemistry targets. Beam may be extracted at two diametrically opposed ports simultaneously (same type of particle at both ports) which allows a very efficient operation of the facility with one port, for instance, supplying radioisotopes for PET imaging and the other one being used for radiochemistry research.

The Cyclotron Radiochemistry Facility is part of the McConnell Brain Imaging Center (BIC) of the MNI. It produces selected positron emitting radioisotopes for medical research and diagnosis. By means of positron emission tomography (PET), the in-vivo investigation of (cerebral) physiological processes in humans is feasible. Cyclotron operation is highly automated, which means reduced operator intervention in the vault and, therefore, reduced radiation exposure to personnel.

The following four positron emitting radioisotopes are produced by the Cyclone 18/9 and used for the labeling of a variety of compounds:

Isotope	**Physical half-life ($T_{1/2}$) in minutes**
^{11}C	20
^{13}N	10
^{15}O	2
^{18}F	110

The above radioisotopes are used to label a variety of compounds which serve to study such quantities as cerebral blood volume, cerebral blood flow, cerebral glucose and oxygen metabolism, protein synthesis rates, cerebral enzyme activities, cognitive activities, neuro-receptor occupancies and many more. These investigations are performed on normal subjects as well as on patients.

The facility occupies an area of approximately 500 m^2 in total with 120 m^2 being used for the cyclotron and associated equipment (control room, power supply room, transformer room) and the remainder for the chemical and radio-chemical laboratories, offices, a washroom and emergency shower, and storage area. Except for a cyclotron secondary cooling circuit remote water chiller located on the roof, the facility is wholly contained within the basement of a single building. Services are drawn from neighboring buildings. The facility places no restrictions on the development of neighboring areas. The buildings and land surrounding the facility are all owned and administered by McGill University.

12.2.1 Area Designation

The cyclotron facility comprises several distinct areas. These are: 1) the vault where the cyclotron is located, 2) the Hot Lab where large quantities (Curies) of radioactive material are transformed into the various PET radiopharmaceuticals mainly using automated synthesis units and hot cells, 3) the clean room where the ready-to-inject products are prepared, 4) the quality control room for the final products, 5) radio-chemistry labs for research activities, 6) chemistry labs (no radioactivity), 7) the cyclotron control room and 8) the power supply room. The cyclotron vault is a zone of "no access" (exclusion area) during accelerator operation. There are, however, two potentially high radiation areas, namely the maze entrance and the Hot Lab. duct. Both areas are marked with radioactive warning signs, and personnel avoid these areas during accelerator operation. All other areas are shielded sufficiently so that no physical access control is necessary while the accelerator is operating. However, because of the nature of the work involved, the entire cyclotron facility, with the exception of the offices, is designated a limited access area.

The clean room is designated a high radiation area whereas the hot lab is an intermediate level facility. The two entrances to the Facility are locked whenever operational personnel are not present in the facility. Access to the facility at other times is through the main entrance only which is kept locked at all times (ring a bell to ask for access).

12.3 Radiation Monitoring in the Cyclotron Facility

12.3.1 Radiation Surveys

The purpose of radiation monitoring is to verify the existence of safe operating levels. Radiation surveys are necessary to establish these levels. Initial, or reference, surveys are performed whenever new target

materials or configurations are used. They consist of the measurement of leakage radiation through vault walls while the accelerator beam is on. In this case, neutron radiation is monitored as well. Special surveys may be conducted whenever radiation hazards are suspected.

Routine surveys are also performed with the beam turned off to establish reference radiation levels. These surveys involve the measurement of residual beta-gamma radioactivity in the cyclotron vault, contamination in the vault, Hot Lab and radio assay areas with the cyclotron shut off. Surveys of contamination and exposure levels in the radioactive material storage room are also performed.

12.3.2 Access Control and Personnel Monitoring

The cyclotron facility is a limited access area with the exception of the offices. The cyclotron vault, the clean room and parts of the Hot Lab are high radiation areas. Access to the facility is through the main entrance (MP024) and through Room MP012 (for authorized personnel only). All entrances are locked whenever operational personnel are not in the facility. Keys to the Facility are controlled.

Routine TLD badge service (body and extremity) is provided for all personnel permanently assigned to the facility. Some workers are also given electronic personal dosimeters (EPDs) with continuous digital read-out and audible alarm capabilities. Visitors and temporary personnel are assigned TLD badges according to their degree of access to radiation areas. All personnel areas are controlled in accordance with the MNI/H Regulations. Occasional visitors must be accompanied by an escort who is a member of the cyclotron unit.

12.3.3 Area Monitoring (gamma radiation)

Continuous monitoring of the gamma dose rate at several locations in the cyclotron facility is performed by a Remote Area Monitoring System. This system consists of three multi-range ion-chamber monitors with associated controls. These ion-chambers are permanently wall-mounted and are located inside the vault, in the Hot Lab, and on the duct leading to the roof.

12.3.4 Exhaust Air Monitoring

The exhaust air from the vault and from the fume hoods in the Hot Lab is monitored with an Eberline Model RMS II Continuous Air Monitor. This monitor provides continuous

measurement of beta-gamma activities of air-borne particulate and gaseous components in the exhaust duct of the ventilation system.

12.3.5 Portable Survey Instruments

In addition to the above radiation detection systems, the following survey instruments are available:

Manuf	Model	Probe	Characteristics	Intended use
Victoreen	290 sn:106116	489-A sn:103074	Geiger pancake	Contamination monitoring
Ludlum	2401-EC sn:267975	built-in	EC Geiger	radiation survey
Victoreen	488A sn:551	built-in	Proportional counter	neutron survey

12.4 Safety Interlock and Warning Systems

The purpose of the safety interlock and a warning system is to ensure that no person is in the vault at any time when the cyclotron is producing hazardous levels of ionizing radiation. The system is "fail-safe", i.e., if the safety procedures are followed, generation of a beam of accelerated particles is possible only when the entrance door is closed.

Details on the functioning of this safety interlock are described in the cyclotron Safety Report which is on file with the CNSC.

12.4.1 Cyclotron Vault Entry and Clearance Sequence

The vault-ready interlock system requires that the cyclotron operator actually enter each bay in the vault and manually reset the interlock system. This operation ensures that the operator himself/herself makes a personal examination of both bays for clearance of personnel before proceeding with beam generation. Furthermore, after cocking the second of the two vault-ready switches, the operator must leave the vault and close the safety door to the vault within the time allotted (30 seconds), or the "ready" condition of the interlock system reverts back to the "stand-by" condition, and the entire procedure

must be repeated. The interlock is fail-safe in that the machine is immediately shut down if any one of the interlock switches is interrupted.

Details on the operation are described in the cyclotron Safety Report.

12.5 Laboratory Safety Instructions

12.5.1 General Safety Practices

Hazards of a general nature include fire and explosion, falls, accidents during lifting and handling of heavy equipment, electrical shock and toxic material release and dispersion. All of these topics are covered in detail in a number of regulations and publications, some of which are contained in the references at the end
of this manual. The RSO, under the direction of the Director of the cyclotron facility, is responsible for the general cyclotron operational safety. He will ensure that all personnel are thoroughly familiar with the safety procedures and that all operations are conducted safely. All experiments, irradiations and processing operations will be reviewed and evaluated with regard to potential non-radiation hazards. Any operation which is considered to be unsafe will be discontinued immediately and will not be resumed until corrected and approved.

Special attention has to be given to electrical hazards because of the existence of high voltage in the accelerator and its power supplies. Standard operating procedures and precautions, which are observed by all personnel, include the following:

1. Never perform a new servicing operation or manipulation alone for the first time.

2. Always use grounding hooks to discharge capacitors.

3. Always have grounding hooks across high-voltage sources while working on the equipment.

4. Never by-pass interlock circuits in the protective interlock system unless absolutely essential. If a by-pass is necessary, then a large sign indicating the by-pass condition must be displayed on the equipment and on the operating console.

12.5.2 General Facility Safety

1. All personnel are required to wear TLD badges or dosimeters where required by CNSC and/or MNI/H Regulations.

2. Eating, drinking, smoking or application of cosmetics is not permitted in the laboratory areas and the cyclotron vault.

3. No food or drink storage is permitted in the radiation areas (only allowed in control room).

4. Protective clothing should be worn in all areas where the handling of radioactive materials may result in contamination.

5. Radioactive materials with substantial radiation levels should be handled with tongs and transferred and stored in approved shielded containers.

6. All radioactive materials and their containers must be labeled in accordance with Section 6.7 of this manual

7. Transfer and control of all radioactive materials should be under the direction of the RSO or a qualified user.

8. Personnel entering exclusion areas should be instructed of the hazards and safety and emergency procedures.

9. All radioactive waste should be deposited in designated containers only and should be packaged and disposed of in accordance with Section 6.12 of the MNI/H Radiation Safety Manual.

10. Decontamination operations should be performed under the direction of the RSO or his qualified alternate.

11. All personnel exposed to radioactive contamination must monitor their hands, feet and clothing before leaving the contaminated area. If contamination is found, decontamination procedures must be followed before leaving the area.

12. Two cyclotron laboratory staff members should be present when the cyclotron is operated or radioisotopes are processed in the Hot Lab.

12.5.3 Vault Safety

1. Each day at the start-up of the cyclotron, an operational check should be made of interlocks, fixed monitors and warning devices.

2. Before the cyclotron vault is secured and an irradiation begun, the target system and/or experimental arrangements should be inspected for conformity with approved safety practices, and the vault cleared of all personnel.

3. Entry into the cyclotron vault should not be permitted without the approval of the cyclotron operator.

4. Vault areas to be occupied for extended periods by personnel should be monitored with portable survey instruments prior to entry.

12.5.4 Hot Lab Safety

1. No radioactive materials are to be washed down the floor or sink drains in the Hot Lab.

2. All materials must be packaged, labeled and monitored in accordance with approved procedures before transfer from the Hot Lab.

3. All personnel in the clean room or the Hot Lab during radioisotope processing operations must monitor their hands and feet before leaving the facility. If contamination is found, decontamination procedures must be followed.

12.5.5 Waste material

All PET radioisotope waste material (C11, N13, O15 and F18) are short lived and are kept for decay before being disposed to waste (see section 7.8 of this manual).

However, cyclotron operation may produce radioactive waste material in the form of activated materials (metallic pieces of hardware, tubing, target material, etc…) with long lived radioisotopes. Activation products may result from fast proton, deuteron or neutron

reactions at or close to the target and from thermal neutrons in surrounding material. Typically a 1 Kg Type 304 Stainless Steel target exposed to a thermal neutron flux of 1e6 per cm2-s for a period of one year will produce Fe-55, Fe-59 and Cr-51 with activities of 226 kBq, 30 kBq and 1.5 MBq respectively.
See: http://www.wise-uranium.org/rnac.html

Any used pieces of hardware that are removed or replaced in the vault are measure with a Geiger counter and activated components are kept for storage or decay inside the cyclotron vault until their disposal.

Special arrangements with the McGill Waste Management Center will be taken to dispose of the material whenever necessary for the longer lived by products (Fe-55 HL is 2.7y).

12.5.6 Emergency Procedures

The purpose of this plan is to provide step-by-step procedures to be followed in the event of an emergency- situation. The goal of any emergency procedure is to prevent injury if none has occurred yet in an accident and to prevent further injury if some has already occurred. Furthermore, every effort must be made to confine and control any radioactivity that may be released as a result of an accident. Safety procedures have been established in the laboratory, which are designed to reduce the possibility of an accident to a minimum; however, it is recognized that even with the most efficient safety program the possibility of an emergency situation still exists. In the Medical Cyclotron Laboratory such emergencies may arise as a result of operational accidents, natural disasters (earthquakes, floods) or civil disturbances such as riots, sabotage, vandalism. In the event of an emergency at least one of the following persons is to be notified. Priority of notification begins at the top of the list.

NAME:	**MNI/H PHONE**	**Emergency phone**
Mr. D. Jolly	514-398-8527	514-455-1162
Ms. M. Kovacevic	514-398-8527	514-669-7263
Dr. Esther Shirrmacher	514-398-8527	
Dr. C. Janicki	514-934-1934 x43866	514-240-1515

Cyclotron personnel should be familiar with the locations of the fire extinguishers, telephones, alarm box and electrical breaker panels as well as with the evacuation routes to be taken in an emergency. The cyclotron is located inside a vault consisting of concrete walls 1m thick. In addition to the cyclotron, there is a variety of electronic equipment and vacuum systems.

The step-by-step procedure to be followed in the event of one or more of the above emergencies is outlined below:

1. Turn off, disconnect or otherwise disable all equipment involved.

NOTE

In the event of an electric shock situation, where the individual, or individuals, are still in contact with the power source and it cannot be shut off, remove the source or the victim (s) using an insulating material such as dry wood, a cloth or a newspapers.

2. Evacuate the area using the hallway exits.

3. Close all doors to isolate any fires.

4. For fires, use the alarm box in the hallway and phone. Give the operator the name and location of the building, room number, fire box number and the nature and extent of the fire, and personnel injuries.

5. Use available fire equipment to extinguish fires.

6. Administer first aid to injured personnel.

7. Notify at least one of the persons on the notification list above.

8. Notify hospital maintenance of the emergency, describing the accident and the extent of any damage, and inform them of any persons who may have been subjected to radioactive contamination.

9. Secure the area, sealing off openings if flooding or gas leaks are present. In the event of a fire, wait until the fire has been completely extinguished and fire department personnel have declared the area safe to enter with regard to fire safety.

10. If radioactivity is involved, check all personnel, including fire and rescue personnel, for contamination. If contamination is found, follow the personnel decontamination procedures.

11. Transfer injured contaminated persons to the special contaminated personnel handling facility located in the Emergency Room of the Royal Victoria Hospital (MUHC).

12. Record as much of the following information as possible:

    a. Time and place of accident.

    b. Names of persons involved.

    c. Radiation monitor readings and instrument settings, if applicable.

    d. Description of accident in as much detail as possible, with the probable cause and the action taken.

NOTE

If radioactive materials are involved, every person who might have been in the area at the time of the accident, or following it, is considered contaminated until a personnel radiation survey has been performed by one of the individuals on the notification list. Those involved in the accident or its control must remain in the immediate vicinity until decontamination has been performed. Do not enter the accident area until an authorized survey and decontamination procedure has been performed and the area has been declared safe by one of the individuals on the notification list above.

N.B.: In the case of a malfunction of the pneumatic tube system used to transfer radioactive samples from the cyclotron facility to the PET-suite, i.e., if a transport container should get stuck underway, the container should be pulled back to the start position by means of a vacuum generator. If this attempt fails, radiation levels in the vicinity of the transport duct will be monitored and personnel working in its vicinity (analysis room WB205) relocated temporarily if needed (e.g. if radiation field larger than 25µSv/hr (2.5mR/hr).

In the case of an emergency entry into the vault, unplug the mains power supply of the Eberline monitoring unit in the Control Room (remember: under normal circumstances, the vault cannot be entered until the vault Eberline monitor reading is below a preset safe radiation level).

In the event of an earthquake, the following action is to be taken in addition to the above procedure:

1. After the earthquake has passed, remain in the vicinity for notification form the MNI/H emergency units or other competent authority.

2. Check the area for fires, floods, gas leaks and other damage and take appropriate action to eliminate or control the hazard.

3. Initiate the step-by-step emergency procedure above.

4. Prepare for possible aftershocks. Secure all rolling equipment or objects that may fall.

DO NOT:

a. Smoke or light a flame.
b. Make unnecessary telephone calls.

12.5.6 Decontamination

The RSO should be notified of all human contamination. Emergency personnel decontamination materials are located on shelves above the sinks in the shop area and in the Hot Lab. Radiation survey meters are located in the quality control room and in the storage cabinet next to the control room.

Decontamination of equipment, furniture and building surfaces should be performed only by a qualified person, an individual who has been trained and/or approved by the RSO. Contaminated areas should be isolated, secured and warning signs posted until decontamination can be performed.

Whenever possible, personnel decontamination should be performed by a qualified person. However, since prompt removal of the contamination is of the utmost importance to reduce the potential hazard, if a qualified person is not readily available, other persons are permitted to perform decontamination following the procedures outlined in this section.

All operating personnel should receive instruction on the use of the portable radiation survey instruments in the facility.

a) Contamination Measurement of an Area

1. Perform preliminary working check of the instrument outside and away from the contaminated area.

2. Ensure that the instrument selected for the measurement is sensitive to the radiation to be measured and is in operating condition.

3. Measure background before and periodically during the survey.

4. When measuring alpha or beta radiation, keep the survey meter shield open and hold the detector window as close to the surface as possible without touching it.

5. Close the shield when measuring gamma radiation.

6. Pass the detector window slowly and carefully over the entire surface. When the meter indicates a radiation level above background, stop and wait for the maximum deflection.

7. If the radiation level exceeds the maximum meter reading, switch to the next highest scale.

8. As soon as reasonably possible, record contamination data in a log-book, including location, radiation level and time of measurement.

b) **Emergency Personnel Decontamination Procedure**

1. On completion of a quick contamination survey, remove all contaminated clothing, including shoes, and place together in a small area to avoid spreading the contamination.

2. Proceed to the nearest sink, and wash all contaminated areas thoroughly with the soap and solutions provided. Be sure to scrub all parts of the hands, under the nails, and across the knuckles with a surgical scrub brush.

3. Dry with paper towels and place the used towels in a radioactive waste container.

4. Check all areas of the body with a survey meter and repeat the washing operation until the radiation level reaches background, or until successive washings fail to lower the level significantly. Do not abrade the skin.

5. Blow nose, using absorbent paper tissue, and save the tissues for assay of radioactivity. Do not attempt to wash out the nasal passages until medical assistance is available.

12.6 Personal Responsibilities

12.6.1 Director of the Medical Cyclotron Facility

All activities that are conducted in the Medical Cyclotron Facility are under the direction and supervision of the Director of the Medical Cyclotron Facility.

No irradiation, beam experiment or radiochemical processing operation may be conducted without his approval. He is responsible for ensuring that all procedures are performed in compliance with MNI/H safety practice.

12.6.2 Chief Cyclotron Operator

The chief cyclotron operator is directly responsible to the Director of the Medical Cyclotron Facility and through him to the Director of the MNI.

All radiochemical operations, including target preparation and processing and handling of the irradiated target, are under the direction of the Director of the Medical Cyclotron. He is responsible for the activities of all individuals involved in these operations and, with their assistance, he ensures compliance with all regulations and safety procedures. Whenever new radio chemical or target handling operations are considered, the operator should consult with the Director of the Medical Cyclotron and the Radiation Safety Officer. He must ensure that all persons working in the Hot Lab are thoroughly familiar with regulations and safety procedures.

12.7 Records

Regulations governing the procedures for initiating and maintaining radiation records and reports are set forth elsewhere in this manual. These Regulations should be followed and, in addition, other records pertinent to the activities of the Medical Cyclotron Facility should be maintained.

12.7.1 Personal Dosimeter and Access Log

Individual TLD badge records are routinely maintained by the chief cyclotron operator and posted at the main entrance to the facility. Additionally, the RSO's office keeps a copy of all exposure reports.

All visitors and transient operational personnel are required to sign in. If personnel dosimeters are required, the relevant information will be entered into the record. Also, the RSO has to file a report to the CNSC within 21 days of noticing that the action level of a worker has been reached.

12.7.2 Radiation Survey Record

This record contains detailed information regarding routine and special surveys as well as safety inspections. Cyclotron equipment maintenance operations, details of unusual incidents and operational conditions etc. are maintained separately.

12.7.3 Radioactive Material Accountability Record

Information and records regarding radioactive material inventories, transfer and waste disposal are maintained in this record. Copies of current valid radioisotope applications from persons and agencies requesting radioisotopes are maintained as a part of the record (e.g., nuclear medicine license of MGH/MUHC).

12.7.4 Radiation Instrument Maintenance and Calibration Record

This record contains the maintenance and calibration information and dates for all radiation survey instruments, gamma area monitors, and direct reading personnel dosimeters (pocket dosimeters). The RSO keeps a record of the compulsory yearly calibrations of all radiation survey meters.

12.7.5 Cyclotron Operational Log

This log contains the operational data of the cyclotron, including pertinent instrument settings, nature of experiment or irradiation, irradiation periods and names of responsible individuals. It is usually maintained by the chief cyclotron operator.

12.8 Radiation Safety Check List

12.8.1 Cyclotron Safety Tests

Consolidated Cyclotron Safety Tests

Based on suggestions by Dr. S. Jovanovich, CNSC, and discussions with Mr. Dean Jolly, Chief Cyclotron Operator.

New: **Every 6 months, 1/2 day** will be requested to perform six-monthly and yearly cyclotron- related safety tests listed below.

Every day: **(new)**

- **Morning inspection,** 5min or less: at the start-up of the cyclotron, an operational check is made of such indispensable safety features as:

    1. "last person out of vault" (i.e., green button in vault)
    2. "emergency cyclotron shut-off operations"(i.e., red button in vault)
    3. "audible warning devices" (i.e., vault bell)
    4. "vault door interlock mechanism" (sliding maze door)
    5. "operational state of interlocked radiation level survey instruments" (Eberline monitors)

    - We have modified the "IBA Cyclone 18/9 Daily Log Sheet "accordingly (see Appendix 14). There are **5 check boxes to be filled in daily** by the operator.

    -The testing of points 1 to 4 is achieved in a single step by making sure that the **vault bell rings**. If either of the buttons or the door interlock is malfunctioning, the door bell will not ring (see circuit diagram).

Every week: **(new: no more weekly routine tests)**

Every 1 month: (new)

- As suggested by Dr. Jovanovich, the 3 **fixed radiation monitors** (Eberline) will be tested in turn, **one monitor every month**, as to their capability to halt cyclotron operation by approaching a gamma radiation source to the monitor and making sure that the cyclotron magnet power supply is shut off by this manoeuvre.

Every 6 months: (new)

- **^{15}O-line leak check** on radioactive gas steel tubing system to prevent escape of ^{15}O-gases into the environment.
- **Monitoring of external cyclotron component activation around target areas** (at 1 foot from targets, at areas where personnel might occasionally perform

Every 12 months: (as before)

- **Calibration of the three fixed radiation monitors** (vault, hot lab and exhaust stack) using a procedure approved by the CNSC.

Whenever required or feasible: (new)

- Thorough **radiation surveys** (gamma and neutrons, see recent survey by Bubble Tech Inc.) shall be performed following modification of target constellations and after major structural and/or functional changes to the cyclotron equipment or its immediate surroundings (shielding, new adjacent facilities) in order to confirm regulatory and safe operating radiation levels.

12.8.2 Interlock and Warning Systems

1. SCRAM Button Tests
2. Vault Buzzer Check
3. Interlock Switches Functional Check

12.8.3 Radiation Monitors

1. Gamma Area Monitoring System (fixed "Eberline" area monitors)
   a. Calibration
   b. Check source reading
   c. Background reading

12.9 Procedures for Handling of Irradiated Targets

12.9.1 Liquid Targets

The liquid target chambers are capable of retaining up to 10 cc of liquid. In general, a one-eighth-inch diameter teflon tube is connected between the solution withdrawal port of the target chamber and a container inside the shielded hot box. Extraction of the irradiated solution is accomplished either by developing a negative pressure at the end of the system inside the hot box and allowing the solution to pass into the container, or by passing a pressurized stream of dry air through the target chamber, thus forcing the solution through the teflon tube and into the container. This latter method permits the flushing out of the system after withdrawal of the irradiated solution. When the irradiated solution has been completely withdrawn, the tube is closed off inside the hot box and the solution container placed in a lead container before removal from the hot box for further processing or transfer to authorized users.

12.9.2 Foils

Foils may break or develop pin-holes during bombardment. Because of the high dose involved, these must be replaced only the following day.

In case of an accidental puncture of target or vacuum chamber foils, the following steps are to be taken:

1. Enter vault as soon as vault access radiation interlock allows the door to be entered.

2. Close all target gas supply valves.
3. Leave vault and close door.
4. Wait 24h to let radioactivity decay (typically over night) and perform repair the next day only.

N.B.: In case of a target foil puncture, the radioactive material produced in the target box will leak into the helium target cooling system which is a closed circuit. If the vacuum foil only is punctured, all radioactive material remains in the target box. If both the target and the vacuum foil are punctured, some radioactive material will be retained in the oil of the vacuum pumps and the rest will be vented to the exhaust system of the facility. Therefore, in the case of any foil puncture, no radioactive material will be leaked into the vault.

It should also be remembered that the vault is under negative pressure with respect to the rest of the facility such that, in the unlikely event that some activity should leak into the vault, this activity would not spread to the other locations of the facility.

12.9.3 Gas Targets

Gaseous targets are irradiated while under positive pressure in cylindrical target chambers. Stainless steel or copper tubing connects the target chamber to a valve station inside one of the fume hoods where collection and treatment of the irradiated gas takes place. Following irradiation, gas is collected either in a holding tank or appropriate solution. Solution traps are also located downstream from the collection system together with terminal holding tanks to ensure that no gas escapes into the surrounding atmosphere until it has sufficiently decayed. In addition, the fume hood is under negative pressure and vented so that no gas escapes into the lab. All solutions are assayed for radioactivity before disposal or removal from the laboratory. Both the laboratory and the fume hood are monitored with a gas monitor.

12.10 References

1. Blatz, Hanson: Radiation Hygiene Handbook, McGraw-Hill, 1959.
2. National Bureau of Standards: Radiological Safety in the Design and Operation of Particle Accelerators (U.S.) Handbook, No. 107, June, 1970.

3. United States Atomic Energy Commission, Division of Operational Safety: Electrical Safety Guide for Research, Safety and Fire Protection Technical Bulletin 13, December 1967.

4. United States Atomic Energy Commission, National Accelerator Safety Committee: Safety Guidelines for High Energy Accelerator Facilities, TID 23992, 1967.

5. United States Department of Health, Education, and Welfare: Particle Accelerator Safety Manual Handbook, MORP 68-12, October, 1968.

6. University of California at Los Angeles, Office of Environmental Health and Safety: UCLA Radiation Safety Handbook, 1964.

7. State of California Department of Public Health, California Radiation Control Regulations, Title 17, California Administrative Code, Chapter 5, Subchapter 4.

8. Federal Register, Standards for Protection Against Radiation, Title 10, Chapter 1, Part 20.

13. Radiation Accident, Emergency Procedures and Incident Reporting

13.1 General Principles

A radiation accident is any unplanned incident or occurrence that results or may result in exposure of human beings to either external or internal radiation. Such an incident can occur in one of two basic ways, the responses to which are different:

a) External exposure without contamination; usually but not invariably resulting from a failure or breakdown of a radiation generator, such as an X-ray unit or cobalt-60 therapy installation, or departure from a procedure designed to ensure safe working with such machines.

b) Contamination; by which is meant the spreading or dispersal of unsealed radioisotopes, which may lead to internal or external exposure or both.

For any emergency situations, the RSO can be contacted at the following numbers:

- RSO: ext. 88-43666 (office) or 88-43862 (cell)
- After normal working hours, "locating" at ext. 88-53333 will contact the RSO (24h on call service)

The MNI/H safety measures for accidents involving radiation are given in Appendix 13.

Incident reporting also includes any of the following situations (Ref. General Nuclear Safety and Control Regulations, SOR/2000-202, May 2000, Section 29):

- Theft or loss of nuclear substances
- Unauthorized release of nuclear substances into the environment
- Attempted breach of security or sabotage
- System failure
- Serious illness, injury or death possibly incurred as a result of licensed activity

A worker who becomes aware of any situation listed above should immediately contact the RSO who may request a written report.

In situations where the RSO must submit a report to the CNSC, the report shall contain the following information:

(a) a description of the situation, the circumstances and the problem, if any, with the radiation device;

(b) the probable cause of the situation;

(c) the nuclear substance, and if applicable, the brand name, model number and serial number of the radiation device involved;

(d) the date, time and location where the situation occurred or, if unknown, the approximate date, time and location, and the date and time of becoming aware of the situation;

(e) the actions that the licensee has taken to re-establish normal operations;

(f) the actions that the licensee has taken or proposes to take to prevent a recurrence of the situation;

(g) if the situation involved an exposure device, the qualifications of the workers, including any trainee, who were involved;

(h) the effective dose and equivalent dose — as those terms are defined in subsection 1(1) of the Radiation Protection Regulations — received by any person as a result of the situation; and

(i) the effects on the environment, the health and safety of persons and the maintenance of security that have resulted or may result from the situation.

A full report will be submitted to the CNSC within 21 days of becoming aware of an incident.

13.2 Accidents involving only external exposure

Accidental exposure of the whole or part of the body to a direct radiation beam or unplanned proximity of high activity sources is unlikely but not impossible. Anybody who knows or suspects that he has been exposed to a direct radiation beam or unshielded source, must immediately report the fact with as much detail as possible to the RSO. The RSO will:
a) Take immediate precautions to avoid the possibility of exposure to others (turn-off the beam, shield the source, cordon off the area, etc.)
b) Arrange for the exposed person to receive a medical examination, including full blood examination if needed.
c) Arrange for a cytogenetic examination if the exposure is likely to be above 200 mSv.
d) Investigate the accident with a view to assessing the dose received by the individual and the cause of the accident.
e) Collect the individual's TLDs' (if worn) and have them send to the Radiation Protection Bureau for dosimetry assessment.
f) Remove or re-shield the source of radiation, if necessary, with the help of provincial or federal radiation safety authorities.
g) Write a detailed report about the accident for submission to the MNI/H, the RSC and pertinent authorities.

13.3 Contamination by nuclear substances

Even though every precaution is taken in order to avoid spills of nuclear substances, a large number of sources are handled under the Consolidated license activities and/or Nuclear Medicine, which increase the probability of an accidental spill. In such an event, care must be taken not to spread the contamination, and clean up procedures should proceed immediately. A spill procedure poster should be posted in every room where nuclear substances are being manipulated (INFO-0743, Appendix 3).

13.3.1 The procedure in case of a spill is as follows:

- Immediately inform persons in the area that a spill has occurred.
- Keep them away from the contaminated area.
- Cover the spill with absorbent material to prevent spread of contamination.
- Estimate the quantity of radioactive material involved in the spill.
- Follow the procedure for either Minor or Major spill below (12.3.2 or 12.3.3).

- Only qualified workers authorized to work with radioisotopes can proceed with the decontamination procedures.

13.3.2 Minor spills: typically less than 100 exemption quantities of a radioisotope, without contamination of personnel:

1. Wearing protective clothing and disposable gloves, clean up the spill using absorbent paper and place in plastic bags for disposal.
2. Wipe test or survey for contamination. Repeat decontamination if necessary until contamination monitoring results meet the license criteria.
3. Check hands, clothing and shoes for contamination.
4. Report the spill and cleanup to person in charge or the RSO if necessary.
5. Record spill details and contamination monitoring results. Adjust inventory and waste records.

13.3.3 Major spills involve more than 100 exemption quantities of a radioisotope, and/or contamination of personnel, or release of volatile material:

For Major spill, call 55555 Code Brown (Appendix 13). The RSO will be contacted and Security will assist in securing the area. Follow the major spill procedure described in the CNSC document INFO-0743 posted in the laboratories.

1. Clear the area. Limit movement of all personnel who may be contaminated until they are monitored.
2. Leave fume hood running in the laboratory (if applicable).
3. Close off and secure the spill area (post warning signs).
4. Notify the RSO or the person in charge immediately.
5. The RSO or person in charge will direct personnel decontamination and will decide about decay or cleanup operations.
6. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap.
7. Follow the procedures for minor spill (if appropriate).
8. Record the names of all persons involved in the spill and details of contamination.
9. The RSO or person in charge will arrange for bioassay measurements if necessary.
10. Submit a written report to the RSO or person in charge.
11. The RSO must submit a report to the CNSC.

13.4 Contaminated patients who need medical attention

a) Isolate patient to protect the environment against the further spread of contaminating radioactive material. Usual surgical isolation technique should be applied.

b) Notify the RSO. The Manager of the RSO has the necessary instrument and knowledge to determine the amount and toxicity of the contamination and would also take care of the decontaminating procedures:

c) Unless very grave injuries make delays impossible, allow the radiation control personnel to decontaminate the patient and surrounding area.

d) If seriously injured, give emergency lifesaving assistance immediately.

e) handle contaminated patient and wound as one would a surgical procedure, i.e. use of gown, gloves, cap, mask, etc.

f) When external contamination is involved, save all clothing and bedding from ambulance, blood, urine, stool, vomitus, personal effects of the patient and your own surgical protective clothing, for the radiation control personnel to deal with. Disposable plastic bags should be used for this purpose, with tags attached to show date and content.

13.5 Fires involving radioactive material

a) The procedures to be followed in the event of a fire are well defined at the Hospital (code red), and they have to be carried out in all instances. The MNI/H code red procedure is reproduced in Appendix 13

b) A 24-H emergency number (88-53333) is available to reach the RSO who will assist the fire unit as necessary. The Laboratory Manager should also be contacted immediately to assist with the location of any hazardous material inside the fire area.

c) The RSO and/or Laboratory Manager will provide to the best of their knowledge precise information to the fire-fighting units about the location of any radioactive material and about the extent of any radiation hazard.

d) Once the fire is dealt with, the RSO will monitor the whole area to verify that the dose rate is within acceptable and safe limits and to detect any contamination level.

e) Only after a careful radiation survey indicating that both the contamination level and the dose rate are below the acceptable limits will the area be allowed open to access.

14. Educations and Training of Personnel

The purpose of a radiation safety program in any institution is to ensure that procedures involving the handling and use of radiation sources are carried out with minimum hazard to all concerned. To this end, the Radiation Safety Committee, the RSO, Responsible Radiation Users and Radiation Supervisors need to establish and maintain close contact with all personnel who work with or near radiation sources. The "human element" is the key factor in the application of all safety rules and regulations. Each department or laboratory, each group or type of personnel and each application or use of radiation sources is associated with specific hazards which require specific safety procedures. Safety implies understanding the working procedures in each area and adjusting or modifying these procedures in order to minimize the hazards.

As an example, all **nuclear medicine technologists** at the MNH/I are **certified professionals,** and the Medical Cyclotron **Radiochemistry Facility personnel** all have experience, some over 10 years, in working with high levels of radioactivity and, to various degrees, have undergone training offered by the manufacturer of the cyclotron.

As a **rule**, any individual who is going to be involved with the handling of radioactive substances or devices at the MNH/I has to register with the RSO. The applicant may attend the **Radiation Safety Course** offered by the Environmental Hygiene and Safety Office (EHS) of McGill University or the training session offered by the RSO at the MNI (see below).

All procedures at the MNH/I are subject to **review and re-evaluation.** Procedural changes and the introduction of new techniques create a need for continuing education of existing personnel as well as for training of new personnel. New employees usually receive on-the-job training and supervision, followed by periodic retraining and further education.

In order to ensure that all persons handling radiation sources receive adequate instruction in the safety aspects of such handling, **the DRS will direct new radiation users (fellows, post-docs, technicians, students) to the RSO** who will assure that these individuals will attend the appropriate training sessions.

The employee is expected to study the assigned documents (e.g. the RSM) and must be given adequate opportunity to discuss and query the material concerned with the Responsible Radiation User, the RSO or other members of the safety organization in order to obtain further information or clarification.

The training of the different groups at the MNI/H is as follows:

14.1 Training of Laboratory Radioisotope Workers

14.1.1 Radiation safety training is mandatory to all workers before being an authorized user under the internal permit issued to handle nuclear substances. A Radiation Safety Training course is offered by the RSO to all new laboratory workers as required by the CNSC Nuclear Safety and Control Regulations. The training covers topics such as:

i) Regulations and Licensing;
ii) Basic Radiation Physics;
iii) Radiation and Risks;
iv) Detection Instruments;
v) Transport and Handling;
vi) Procedures for Working in Laboratories.

14.1.2. A training certificate is issued for those who have completed the training session. Workers are asked to sign a record of training where they certify to have understood *the regulations, obligations, radiation dose limits and levels that are associated with the designation as authorized users in radioisotope laboratories at the MNI/H.*

14.1.3. Any person involved with the packaging and the transport of nuclear substances must also be trained in the Transport of Dangerous Goods (TDG, Class 7). The RSO offers a basic TDG training module and will issue a TDG certificate to the employee if the employer is satisfied hat the employee is adequately trained. The RSO may also refer the employee to an outside firm for advanced training if deemed necessary.

14.1.4. The TDG certificate is valid for a period of three years (ground transport) or two years (air transport) and must be renewed after that period by the employer in order for the employee to continue packaging and offering for transport radioactive packages. The employer may re-issue the TDG certificate if he considers that the employee is adequately trained (note that formal TDG retraining after the 2 or 3 year period is recommended but not mandatory).

14.1.5. The TDG certificate must be produced if asked by an inspector. The certificates must be kept for 3 years after the end of the employment or expiry of the license.

14.1.6 As part of the services being offered to the MNI/H by the McGill University Waste Management Program, a 2h training session on how to use the McGill Radioisotope Tracking System (MyLAB) for tracking radioisotope usage, waste and disposal will be held at the MNI/H when warranted.

14.1.7 Animal care workers who take care of animals injected with nuclear substances in radioisotope laboratories must be trained in radiation safety as described in section 13.1.1 of this manual.

14.2 Training of Gammacell Operators

13.2.1. A basic radiation safety course is offered by the RSO for the users of the Gammacell 1000 Irradiator. The one-hour training covers topics such as: Regulations and Licensing; Basic Radiation Physics; Radiation and Risks.

13.2.2. na

13.2.3. A detailed Instruction Manual and Owner's guide for the Gammacell 1000 Irradiator is also available from the Laboratory Managers for consultation.

14.3 Retraining

14.3.1 The RSO will offer Radiation Safety refresher courses to all employees who are referred by their employer or supervisor for retraining.

14.3.2 The RSO will offer to any employee the full Radiation Safety Training course for the purpose of retraining. Depending on the retraining requirements, the employee may choose to participate only to some of the modules presented during the full day training session if authorized by his/her supervisor.

14.3.3 Refresher course or retraining is not mandatory. However, it may be necessary when there are important changes to the regulations, internal policy or procedures if these have a direct impact on the laboratory activities. The RSO will inform all authorized users of any such changes and set up special training sessions accordingly. This may take the form of formal training sessions (course), personal training during routine inspections or visit to the laboratories, or written communications and documentations. All retraining sessions will be recorded in the users' record of training.

14.3.4. A retraining or refresher course is also recommended for workers who have remained inactive for one year or more, or when there are important changes made to the laboratory procedures by the RSO. The RSO will send a general notice when such changes occur and will recommend training as deemed necessary.

14.4 Technologists in Nuclear Medicine and Diagnostic Radiology

They are qualified professionals who received academic and practical training and are practicing "Nuclear Energy Workers" or “Radiation Workers”. They are in constant communication with the RSO, may analyze or discuss any radiation issues or the exposure records together. Seminars are held when warranted or for special purposes (e.g. new regulations, treatment or equipment).

14.5 Security and maintenance personnel

With the co-operation of those in charge of these departments, seminars are given at the most convenient time for all to attend. The main topics discussed are: possible accidents on the premises of the MNI/H, radiation safety procedures in case of emergency and receiving, storage and disposal procedures at the MNI/H.

Refresher training will be provided as deemed necessary if the MNI/H working procedures or CNSC regulations change. Refresher training will also be given is declared necessary by the RSO.

14.6 Medical and nursing personnel in ICU, Emergency, OR, etc.

Lectures are held in these departments at the convenience of the personnel involved.

APPENDIX 1:

MNI/H CNSC Licenses

Licenses are posted on WB2 floor. Please contact the RSO office for details.

Montreal Neurological Institute
and Hospital

A Teaching and Research Institute at McGill University

APPENDIX 2:

Nuclear Energy Worker Designation

Montreal Neurological Institute and Hospital

A Teaching and Research Institute at McGill University

NOTIFICATION OF NUCLEAR ENERGY WORKER STATUS

Name: _____ Sex: M / F

SIN: _____

Date of Birth: _____

Department and Site _____

In accordance with the *Nuclear Safety and Control Act* and *Regulations* of Canada, this is to inform you that you are a NUCLEAR ENERGY WORKER. A Nuclear Energy Worker as defined in the *Nuclear Safety and Control Act* means

"a person who is required, in the course of the person's business or occupation in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there are reasonable probability that the person may receive a dose of radiation that is greater then the prescribed limit for the general public."

As required by the *Radiation Protection Regulations* (RPR), I have been informed in writing of:

a) the risks associated with radiation to which I may be exposed in the course of my work, including the risk associated with exposure of an embryo and foetus to radiation;
b) the applicable dose limits prescribed in the RPR;
c) of my expected radiation dose levels;
d) for females, of my rights and obligations should I become pregnant

I understand the risks, my obligations, and the radiation dose limits and levels that are associated with being designated a NEW.

Signature of Worker: _____

Signature of Radiation Safety Officer: _____

Date: _____ (Y/M/D)

Montreal Neurological Institute and Hospital
A Teaching and Research Institute at McGill University

Notification du statut de travailleur du secteur nucléaire

Nom: _____ Sexe: M / F

NAS: _____

Date de naissance: _____

Département et Site _____

Conformément à la *Loi sur la sûreté et la réglementation nucléaires* et aux *Règlements* du Canada, la présente vous informe que vous êtes un TRAVAILLEUR DU SECTEUR NUCLÉAIRE. Selon la définition de la *Loi sur la sûreté et la réglementation nucléaires*, l'expression travailleur du secteur nucléaire s'entend d'une

"personne qui, dans le cadre de ses affaires ou occupations, doit effectuer des tâches avec une substance nucléaire ou dans une installation nucléaire dans des circonstances entraînant une probabilité raisonnable de recevoir une dose de rayonnement supérieure à la limite réglementée pour le grand public".

Conformément aux exigences du *Règlement sur la radioprotection* (RRP), j'ai été avisé par écrit :

a) des risques entraînés par le rayonnement auquel je peux être exposé durant le cours de mon travail, y compris les risques entraînés par l'exposition d'un embryon ou d'un fœtus;
b) des limites de doses applicables précisées dans le RRP;
c) des niveaux de dose de rayonnement auxquels je dois m'attendre;
d) (pour les femmes) de mes droits et de mes obligations si jamais je devenais enceinte.

Je connais les risques, mes obligations et les niveaux et les limits de dose de rayonnement associés à la désignation comme travailleur du secteur nucléaire.

Signature du travailleur: _____

Signature du responsable de la radioprotection: _____

Date: _____ (A/M/J)

Montreal Neurological Institute and Hospital

A Teaching and Research Institute at McGill University

Requirements of the Licensee

As a condition to the Radiation Protection Regulations (SOR/2000-203) the following provision of information must be given to all nuclear energy workers:

Pregnant Nuclear Energy Workers (RPR Section 11)

11.(1) Every nuclear energy worker who becomes aware that she is pregnant shall immediately inform the licensee in writing.

(2) On being informed by a nuclear energy worker that she is pregnant, the licensee shall, in order to comply with the legal limits shown in the preceding table (4 mSv for the balance of the pregnancy), make any accommodation that will not occasion costs or business inconvenience constituting undue hardship to the licensee.

Effective dose limits (RPR Section 13)

13.(1) Every licensee shall ensure that the effective dose received by and committed to a person described in column 1 of an item of the table to this subsection (below), during the period set out in column 2 of that item, does not exceed the effective dose set out in column 3 of that item".

	Column 1	Column 2	Column 3
Item	Person	Period	Effective Dose (mSv)
1.	Nuclear energy worker, including a pregnant nuclear energy worker	(*a*) One-year dosimetry period	50
		(*b*) Five-year dosimetry period	100
2.	Pregnant nuclear energy worker	Balance of the pregnancy	4
3.	A person who is not a nuclear energy worker	One calendar year	1

Equivalent dose limits (RPR Section 14)

14.(1) Every licensee shall ensure that the equivalent dose received by and committed to an organ or tissue set out in column 1 of an item of the table to this subsection (below), or a person described in column 2 of that item, during the period set out in column 3 of that item, does not exceed the effective dose set out in column 4 of that item.

	Column 1	Column 2	Column 3	Column 4
Item	Organ or Tissue	Person	Period	Equivalent Dose (mSv)
1.	Lens of an eye	(*a*) Nuclear energy worker	One-year dosimetry period	150
		(*b*) Any other person	One calendar year	15
2.	Skin	(a) Nuclear energy worker	One-year dosimetry period	500
		(*b*) Any other person	One calendar year	50
3.	Hands and feet	(*a*) Nuclear energy worker	One-year dosimetry period	500
		(*b*) Any other person	One calendar year	50

Emergencies (RPR Section 15)

15.(1) During the control of an emergency and the consequent immediate and urgent remedial work, the effective dose and the equivalent dose may exceed the applicable dose limits prescribed by sections 13 and 14, but the effective dose shall not exceed 500 mSv and the equivalent dose received by the skin shall not exceed 5 000 mSv.

(2) Subsection (1) does not apply in respect of pregnant nuclear energy workers who have informed the licensee in accordance with subsection 11(1).

(3) The dose limits prescribed by sections 13 and 14 and subsection (1) may be exceeded by a person who acts voluntarily to save or protect human life.

Radiation Risks

The International Commission on Radiological Protection (ICRP) has published risk factors of cancer lethality by radiation, which is summarized in the following table:

Table 19-3.
ICRP Summary of Risks of Cancer Lethality by Radiation

	HIGH DOSE HIGH DOSE RATE	LOW DOSE LOW DOSE RATE
Working population	8×10^{-2} per Sv	4×10^{-2} per Sv
Whole population	10×10^{-2} per Sv	5×10^{-2} per Sv

(International Commission on Radiological Protection: Recommendations. Annals of the ICRP Publication 60. Oxford, Pergamon Press, 1990)

Assuming an effective dose of 5 mSv over a one-year dosimetry period for a NEW working in an hospital environment (e.g. Nuclear Medicine Technologist), this results in an Excess Relative Risk (ERR) of 0.005 Sv x 0.04/Sv = 0.00020, or 0.02% per one-year period of acquiring cancer. This should be compared to a lifetime probability of acquiring cancer of about 40% from all causes.[1]

[1]Statistics Canada, http://www.statcan.ca/english/Pgdb/health25a.htm

APPENDIX 3A – Transport of Dangerous Goods (Class 7)

Packaging and Transport of Class 7 (radioactive) Dangerous Goods

Introduction

Transport and Packaging of Class 7 (radioactive) Dangerous Goods must be done in compliance with the CNSC and Transport Canada's TDG regulations. This brief procedure is intended only as a refresher since any one who packages, offers for transport or transports Class 7 DG must be adequately trained to the employer's satisfaction and have a certificate of training issued by his employer or work in the presence of a trained person. The training must be up-to-date with the latest regulations involved and renewed every 24 months for air transport.

The following regulatory documents for the transport of DG are available online at the links indicated below (accessed November 27 2008). A trained person must be familiar will all items related to Class 7 material from the documents below before being authorized to offer Class 7 material for transport at the MUHC.

- *TDG Regulations consolidated to include SOR/2008-34 (Amendment 6)*
  http://www.tc.gc.ca/tdg/clear/part1.htm

- *Packaging and Transport of Nuclear Substances Regulations (SOR/2000-208)*
  http://laws.justice.gc.ca/en/n-28.3/sor-2000-208/154290.html

- *Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Amended) Safety Requirements, Safety Standards Series No. TS-R-1*
  http://www-ns.iaea.org/standards/documents/default.asp?sub=200
  (We will refer to this document as *IAEA TS-R-1*).

In the following, the instructions for identifying and packaging "Excepted", "Type A", and "Industrial" packages are given. These are the types of packages found most frequently at the MUHC for radioisotope laboratory and nuclear medicine. For Type B and C packages, special provisions will be taken in accordance with these same regulations when required.

The shipper's responsibilities are:

1 - Classifying and packaging the DG
2 - Marking and labeling the package
3 - Filling out documentation for shipping
4 - Verifying placarding

In the following, the procedures for filling out each step of the process are detailed. A complete IATA checklist to verify shipments at origin is given at the end of this document. Similar checklists are available from FEDEX.

1. Classifying and Packaging

Before allowing a carrier to take possession of a dangerous good for transport, the consignor must identify and determine the classification of the dangerous good in accordance with the TDG regulations. Identification and classification of Class 7 material is done using the *IAEA TS-R-1* document. If the package to be shipped was previously identified and classified by a previous consignor in accordance with the TDG regulation, the present consignor is allowed to use the classification determined by the previous consignor or by the manufacturer.

The classification of Class 7 material is based of two quantities A1 and A2 defined in the *IAEA TS-R-1* document for the different isotopes.

Below is a partial list for selected isotopes (a complete list can be found in *IAEA TS-R-1* document). A1 refers to special form material while A2 refers to normal form material.

Radionuclide	A1 (GBq)	A2 (GBq)
Americium-241	10,000	1
Carbon-14	40,000	3,000
Cadmium-109	30,000	2,000
Californium-252	50	3
Curium-244	20,000	2,000
Cobalt-57	10,000	10,000
Cobalt-60	400	400
Cesium-137	2,000	600
Iron-55	40,000	40,000
Iodine-125	20,000	3,000
Iodine-129	Unlimited	Unlimited
Iodine-131	3,000	700
Iridium-192	1,000	600
Lead-210	1,000	50
Nickel-63	40,000	30,000
Phosphorus-32	500	500
Radium-226	200	3
Strontium-90	300	300
Technetium-99	40,000	900
Tritium	40,000	40,000

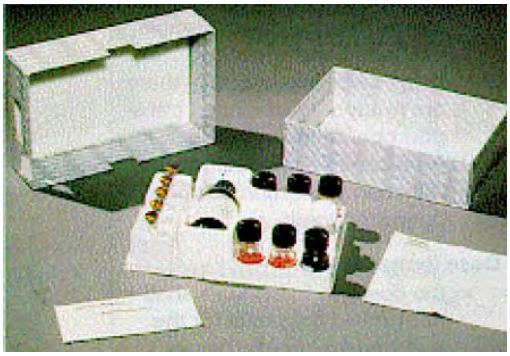
Table 1. List of radionuclide values for selected isotopes

The types of packaging for radioactive material will depend on the amount of material to be shipped (activity limit) as determined above. Most common types of packaging for MUHC radioisotope laboratories products will be either "Excepted packages", "Type A package" and "Industrial package" (for LSA-I material).

For any package, the non-fixed contamination on external surfaces of packages shall be kept as low as practicable and shall not exceed the following limits:

(a) For beta, gamma and low toxicity alpha emitters 4 Bq/cm2
(b) For all other alpha emitters 0.4 Bq/cm2

Excepted Packages



The activity limit for "Excepted package" is given in the table below:

Physical state of contents	Instrument or article		Materials
	Item limits[a]	*Package* limits[a]	*Package* limits[a]
Solids:			
special form	$10^{-2} A_1$	A_1	$10^{-3} A_1$
other forms	$10^{-2} A_2$	A_2	$10^{-3} A_2$
Liquids	$10^{-3} A_2$	$10^{-1} A_2$	$10^{-4} A_2$
Gases			
tritium	$2 \times 10^{-2} A_2$	$2 \times 10^{-1} A_2$	$2 \times 10^{-2} A_2$
special form	$10^{-3} A_1$	$10^{-2} A_1$	$10^{-3} A_1$
other forms	$10^{-3} A_2$	$10^{-2} A_2$	$10^{-3} A_2$

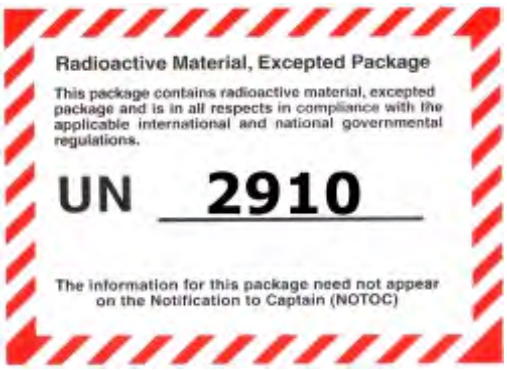
Table 2: Activity limits for excepted packages (*IAEA T-SR-1*, p.39)

Any package that meets the requirements from the table above can be shipped as an "Excepted Package". Another condition is that the dose rate must not exceed 5 microSv/h outside the package.

Excepted packages must be accompanied by a document which includes the shipping name and UN number of the material. If transporting by road, an excepted package of radioactive material must be marked on the outside of the package with the following:

1. The identification mark of the consignor or the consignee
2. The UN number of the radioactive material
3. The permissible gross mass of the package, if the mass is above 50kg.

Air carriers require that the UN number be marked a label entitled “Radioactive Material, Excepted Package" with the red hatching and additional info as illustrated below.



Sending excepted packages through Canada Post

Dangerous Goods, as defined by the Transportation of Dangerous Goods (Clear Language) Regulations (TDGR), are non-mailable matter, except, if permitted by the TDGR, the mailer of the dangerous goods offers them to Canada Post for transport, and if the Corporation is capable of handling them. Canada Post will not otherwise accept packages that contain dangerous goods or that display dangerous goods symbols.
(http://www.canadapost.ca/tools/PG/manual/PGnonmail-e.asp)

According to par 580 of the *IAEA T-SR-1*, an excepted package in which the activity of the radioactive contents does not exceed one tenth of the limits prescribed in Table 2 (above) may be accepted for international movement by post, subject in particular to the following additional requirements as prescribed by the Acts of the Universal Postal Union:

> (a) it shall be deposited with the postal service only by consignors authorized by the national authority;
> (b) it shall be dispatched by the quickest route, normally by air;
> (c) it shall be plainly and durably marked on the outside with the words “RADIOACTIVE MATERIAL — QUANTITIES PERMITTED FOR MOVEMENT BY POST”; these words shall be crossed out if the packaging is returned empty;
> (d) it shall carry on the outside the name and address of the consignor with the request that the consignment be returned in the case of non-delivery; and
> (e) the name and address of the consignor and the contents of the consignment shall be indicated on the internal packaging.

Type A packages

Type A packages shall not contain activities greater than the following:

(a) for special form radioactive material - A1; or
(b) for all other radioactive material - A2.

For mixtures of radionuclides, please refer to par 404 of the *IAEA T-SR-1* document.

Industrial Packages (LSA-I material)

The waste containers that are collected from the radioisotope laboratories are transferred to the McGill Waste Management center periodically as Industrial Packages, Type IP-1 (transported under excusive use). The wastes are classified *UN 2912, Radioactive Material, Low Specific Activity (LSA-I), non-fissile or fissile excepted*.

For the waste products, the following definition for LSA-I applies (*IAEA T-SR-1*, p.9):

> *Radioactive material in which the activity is distributed throughout and the estimate average specific activity does not exceed 30 times the values for activity concentration (for exempt material) specified in pars 401-406 (IAEA T-SR-1 document).*

For mixtures of radionuclides, the activity concentration for exempt material can be estimated using the formula in par. 404 of the *IAEA T-SR-1* document.

2. Marking and Labeling

Class 7 packages (other than excepted packages) require complete shipping description which includes:

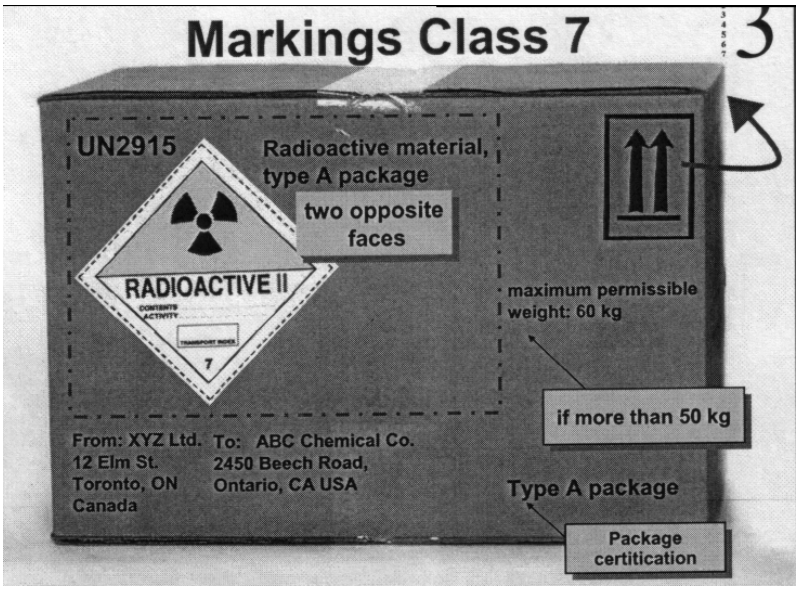
- Identification number (UN number)
- Shipping name
- Categories and Transport Index (TI)

The categories (I, II or III) and Transport Index are defined in CNSC document INFO-0744 in Appendix 3 of the RSM. Most frequently used UN numbers and shipping names are given in the table below (excerpt from Schedule 2 of the TDG regulation).

Col.1 UN number	Col.2 Shipping Name and Description	Col.3 Class	Col.4 Packing Group/ Category	Col.5 Special Provisions	Col.6 Explosive Limit and Limited Quantity Index	Col.7 ERAP Index	Col.8 Passenger Carrying Ship Index	Col.9 Passenger Carrying Road or Rail Index	Col.10 Marine Pollutant
UN2908	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - EMPTY PACKAGING	7		72	0				
UN2909	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - ARTICLES MANUFACTURED FROM DEPLETED URANIUM; RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - ARTICLES MANUFACTURED FROM NATURAL THORIUM; or RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - ARTICLES MANUFACTURED FROM NATURAL URANIUM	7		72	0				
UN2910	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - LIMITED QUANTITY OF MATERIAL	7		72	0				
UN2911	RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - ARTICLES; or RADIOACTIVE MATERIAL, EXCEPTED PACKAGE - INSTRUMENTS	7		72	0				
UN2912	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-I) non-fissile or fissile excepted	7		74	0	100			
UN2913	RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-I), non-fissile or fissile excepted; or RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-II), non-fissile or fissile excepted	7		74	0				
UN2915	RADIOACTIVE MATERIAL, TYPE A PACKAGE, non-special form, non-fissile or fissile excepted	7		74	0				
UN2916	RADIOACTIVE MATERIAL, TYPE B(U) PACKAGE, non-fissile or fissile excepted	7		74	0				
UN2917	RADIOACTIVE MATERIAL, TYPE B(M) PACKAGE, non-fissile or fissile excepted	7		74	0				
UN3321	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-II), non-fissile or fissile excepted	7		74	0	100			
UN3322	RADIOACTIVE MATERIAL, LOW SPECIFIC ACTIVITY (LSA-III), non-fissile or fissile excepted	7		74	0	100			
UN3332	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, non-fissile or fissile excepted	7		74	0				
UN3333	RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, FISSILE	7		74	0	0		Forbidden	

Table 3.: UN number and Shipping names for Class 7 radioactive Materials

An illustration of proper labeling for type A package is illustrated below:



All marks and labels on the package:

- must not be covered or obscured by any other item
- must not touch more than one face package
- must be displayed in size and orientation as designed

The radioactive I, II or III label (see above) must be filled out and include the isotope, activity and Transport Index value (if applicable).

Package must also be identified with UN number and proper shipping name on two opposite faces as illustrated above, the double arrows (on two opposite faces), complete address for the consignor and the consignee (from and to) and package certification.

3. Documentation

The shipper's main responsibility for documentation are to:

- produce a compliant document
- maintain a copy of document for 2 years
- provide copies to the carrier

For transportation, the shipper must provide the following documents:

- A declaration for dangerous good
- Any supporting documents
- An airway or way bill

The shipper's declaration must be in IATA format (see next page), be printed and completed in English, be completed manually or mechanically and be signed.

The following information must be included on a shipping document:

- the name and address of the place of business in Canada of the consignor;
- the date the shipping document
- the description of each of the dangerous goods, in the following order:
- the shipping name
- the primary class (class 7 for radioactive material)
- the UN number
- the quantity of dangerous goods (SI units)
- a “24-Hour" emergency number at which the consignor can be reached

In addition, for LSA-I material (UN 2912) in quantities of more than 100 Kg or Liters (ERAP Index=100), the shipping document must include the following information:

- the reference number of the emergency response assistance plan issued by Transport Canada preceded or followed by the letters “ERAP”
- the telephone number, including the area code, to call to have the emergency response assistance plan activated immediately.

For Type-A package, the person who packages the radioactive material shall keep a record of the following information:

- the technical specification of its design
- the type, quantity, form of the radioactive material it is designed to contain
- documents that demonstrates that the package meets the regulatory , including a written quality assurance program
- instructions for packaging, transport, receiving, maintenance and unpacking

SHIPPER'S DECLARATION FOR DANGEROUS GOODS
DÉCLARATION DE L'EXPÉDITEUR POUR MARCHANDISES DANGEREUSES

Shipper
Expéditeur

Air Waybill No.
No de L.T.A.

Page of Pages
Page de pages

Shipper's Reference Number *(optional)*
N° de référence de l'expéditeur *(facultatif)*

Consignee
Destinataire

Two completed and signed copies of this Declaration must be handed to the operator.
Deux copies de cette déclaration dûment remplies et signées doivent être remises à l'exploitant.

TRANSPORT DETAILS
RENSEIGNEMENTS SUR LE TRANSPORT

This shipment is within the limitations prescribed for: *(delete non-applicable)*
Cette expédition est dans les limites autorisées pour: *(biffer la mention inutile)*

PASSENGER AND CARGO AIRCRAFT / AERONEF PASSAGERS ET CARGO	CARGO AIRCRAFT ONLY / AERONEF CARGO SEULEMENT

Airport of Departure
Aéroport de départ

Airport of Destination:
Aéroport de destination:

WARNING
Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties. This Declaration must not, in any circumstances, be completed and/or signed by a consolidator, a forwarder or an IATA cargo agent.

AVERTISSEMENT
Le non-respect sur quelque point que ce soit de la Réglementation sur le transport des marchandises dangereuses peut constituer une infraction aux lois en vigueur, punissable par la loi. Cette déclaration ne peut en aucun cas être remplie et/ou signée par un groupeur, un transitaire ou une agence messagerie IATA.

Shipment type: *(delete non-applicable)* *Type d'envoi (biffer la mention incorrecte)*

NON-RADIOACTIVE / NON-RADIOACTIF	RADIOACTIVE / RADIOACTIF

NATURE AND QUANTITY OF DANGEROUS GOODS
NATURE ET QUANTITÉ DE MARCHANDISES DANGEREUSES

Dangerous Goods Identification / Identification des marchandises dangereuses					Quantity and type of packing / Quantité et type d'emballage	Packing Inst. / Instructions d'emballage	Authorization / Autorisation
Proper Shipping Name / Appellation réglementaire	Class or Division / Classe ou division	UN or ID No. / N°. UN ou ID.	Packing group / Groupe d'emballage	Subsidiary Risk / Risque subsidiaire			

Additional Handling Information
Renseignements complémentaires concernant la manutention

24 hr. Emergency Contact Tel. No.:
No de téléphone d'urgence (24 heures):

Shipment is made under the provisions of ICAO
L'envoi est effectué conformément aux dispositions de l'OCAI

I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to appliable international and national governmental regulations.

Par la présente, je déclare que les renseignments relatifs à la description du contenu du chargement et à l'appellation réglementaire du produit expédié sont complets et exacts; et que le contenu est correctement classé, emballé, identifié, étiqueté/placardé et qu'il est conforme à tous égards aux règlements gouvernementals nationaux et internationaux en matière de transport.

Name/Title of Signatory
Nom/Titre du Signataire

Place and Date
Lieu et Date

Signature/
Signature
(See warning above)
(Voir-avertissement ci-dessus)

FM-USFL83B ICC Centre de Conformité Dorval, Québec - Mississauga, Ontario - Dartmouth, Nouvelle-Écosse Imprimé au Canada 07/01

Special provisions

(72 in col 5 of Schedule 2)

If the dangerous goods meet the definitions and criteria for inclusion in other classes in accordance with Part 2 (Classification) of the TDG regulation, the subsidiary class or classes must be shown on a shipping document along with the primary class for the dangerous goods.

(74 in col 5 of Schedule 2)

1. If these dangerous goods have a subsidiary class or classes, they must be assigned to Packing Group I, II or III, as appropriate, in accordance with the criteria in Part 2 of the TDG regulation (Classification) for the subsidiary class that takes precedence.

2. The description of the subsidiary class or classes of the dangerous goods and the labels and placards must be displayed on a means of containment in accordance with the requirements in Part 4 of the TDG regulation (Dangerous Goods Safety Marks).

3. The description of the subsidiary class or classes on a shipping document must be in accordance with Part 3 of the TDG regulation (Documentation).

4. Verifying Placarding

It is the responsibility of the shipper to verify the placards on the transporting vehicle. Placards are required on all 4 sides of the transport vehicle if DG meet one of the following:

- In bulk
- are class 7 category III
- are in quantities above 500 kg
- if an ERAP is required (UN2912, UN3321, UN3322)

For class 7 DG, the radioactive material placard is illustrated below:

5. Additional Information

For any packaging and transport issues that are not covered in this short document, please contact the MUHC Radiation Safety Office.

APPENDIX 3:

Posters and Radiation Warning Signs

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO-0728-1

BASIC LEVEL
Use of Unsealed Nuclear Substances

This room has been classified as "basic level" for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission guidelines. Below is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)	Room identification

- Do not eat, drink, store food, or smoke in this room.
- In case of a spill or incident involving a nuclear substance, follow emergency procedures and notify the Radiation Safety Officer.
- Clearly identify work surfaces used for handling nuclear substances.
- Use protective clothing and equipment when working with nuclear substances.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.

A room is classified as "basic level" for the use of unsealed nuclear substances when more than one exemption quantity is handled and where the largest quantity (in becquerels) of a substance handled by any worker does not exceed 5 times its corresponding annual limit of intake (in becquerels). Contact your Radiation Safety Officer for a list of annual limits of intake.

For more information, contact: Canadian Nuclear Safety Commission, Directorate of Nuclear Substance Regulation, P.O. Box 1046, Station B, Ottawa, Ontario, K1P 5S9. Telephone: 1-888-229-2672. Facsimile: (613) 995-5086.

Canada

INTERMEDIATE LEVEL
Use of Unsealed Nuclear Substances

This room has been classified as "intermediate level" for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission guidelines. Below is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)	Room identification

- Do not eat, drink, store food, or smoke in this room.
- Wear appropriate dosimeter at all times.
- In case of a spill or incident involving a nuclear substance, follow emergency procedures and notify the Radiation Safety Officer.
- Clearly identify work surfaces used for handling nuclear substances.
- Use protective clothing and equipment when working with nuclear substances.
- After working with nuclear substances, monitor work area for contamination.
- Wash hands regularly and monitor them for contamination frequently.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.

A room is classified as "intermediate level" for the use of unsealed nuclear substances where the largest quantity (in becquerels) of a substance handled by any worker does not exceed 50 times its corresponding annual limit of intake (in becquerels). Contact your Radiation Safety Officer for a list of annual limits of intake.

For more information, contact: Canadian Nuclear Safety Commission, Directorate of Nuclear Substance Regulation, P.O. Box 1046, Station B, Ottawa, Ontario, K1P 5S9. Telephone: 1-888-229-2672. Facsimile: (613) 995-5086.

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO-0728-3

HIGH LEVEL
Use of Unsealed Nuclear Substances

This room has been classified as "high level" for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission guidelines. Below is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)	Room identification

- Do not eat, drink, store food, or smoke in this room.
- Restrict access to authorized workers only.
- Wear appropriate dosimeter at all times.
- In case of a spill or incident involving a nuclear substance, follow emergency procedures and notify the Radiation Safety Officer.
- Work in a fumehood when required by the Radiation Safety Officer.
- Clearly identify work surfaces used for handling nuclear substances.
- Wear protective clothing and equipment at all times.
- After working with nuclear substances, monitor work area for contamination.
- Wash hands regularly and monitor them for contamination frequently.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.

A room is classified as "high level" for the use of unsealed nuclear substances where the largest quantity (in becquerels) of a substance handled by any worker does not exceed 500 times its corresponding annual limit of intake (in becquerels). Contact your Radiation Safety Officer for a list of annual limits of intake.

For more information, contact: Canadian Nuclear Safety Commission, Directorate of Nuclear Substance Regulation, P.O. Box 1046, Station B, Ottawa, Ontario, K1P 5S9. Telephone: 1-888-229-2672. Facsimile: (613) 995-5086.

Canada

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO-0728-4/Rev. 1

NUCLEAR MEDICINE
Use of Unsealed Nuclear Substances

This room has been classified as a "nuclear medicine" room for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission guidelines. Below is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)	Room identification

- Do not eat, drink, store food, or smoke in this room.
- Wear appropriate dosimeter at all times.
- In case of a spill or incident involving a nuclear substance, follow emergency procedures and notify the Radiation Safety Officer.
- Work in a fumehood when required by the Radiation Safety Officer.
- Wear protective clothing and equipment at all times.
- Wash hands regularly and monitor them for contamination frequently.
- Perform thyroid screening or bioassay when required.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.

A room is classified as "nuclear medicine" for the use of unsealed nuclear substances if the nuclear substance is prepared for or administered to a person.

For more information, contact: Canadian Nuclear Safety Commission, Directorate of Nuclear Substance Regulation, P.O. Box 1046, Station B, Ottawa, Ontario, K1P 5S9. Telephone: 1-888-229-2672. Facsimile: (613) 995-5086.

Cat. No.: CC172-36/2005E-PDF
ISBN: 0-662-42107-8

Canada

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

INFO-0742

PROPER CARE AND USE OF PERSONAL DOSIMETERS

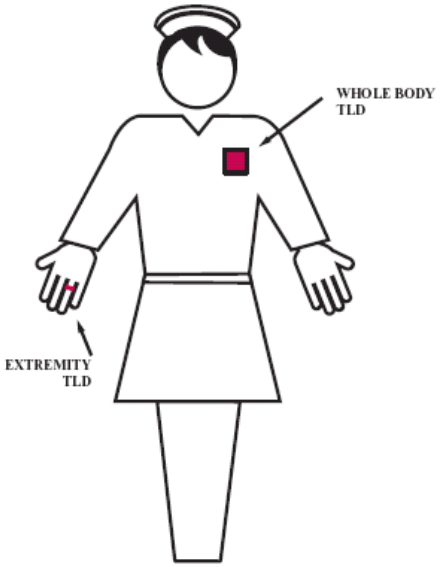
This poster describes the proper handling, wearing and storage of whole body and extremity dosimeters. These dosimeters are commonly referred to as Thermo Luminescent Dosimeters or TLDs. Your TLD measures the amount of radiation to which you are exposed. Here are some useful tips:

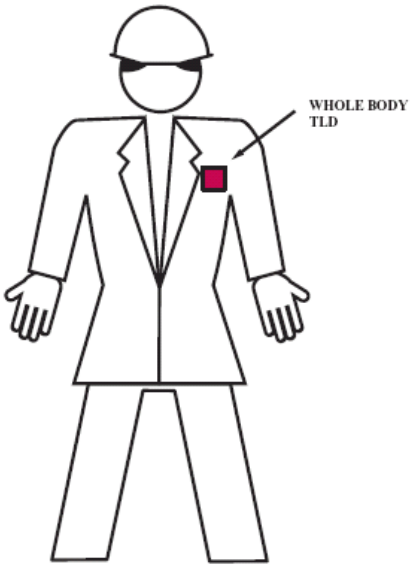
HANDLING

1. Do not expose the TLD to high temperature, water, direct sunlight or fluorescent light.
2. Change the plaques in a clean, dry area away from direct light and avoid direct skin contact.

WEARING

3. Clip your whole body TLD firmly to your clothing between your waist and neck.
4. If necessary, you may wear a second TLD on the area of your body most likely to receive the highest dose.
5. Extremity TLDs (rings) should be worn facing the source of radiation.
6. If you lose or damage your TLD you should stop working with radiation until you receive a replacement.





STORAGE

7. Store TLDs in a holder or rack when not in use.
8. TLDs are best stored in a low radiation background area away from direct light and heat.
9. It is good practice to keep extra TLDs as replacements for lost or damaged ones.

For more information, contact: Canadian Nuclear Safety Commission, Directorate of Nuclear Substance Regulation, P.O. Box 1046, Station B, Ottawa, ON K1P 5S9. Telephone: 1-888-229-2672. Fax: (613) 995-5086.

Canada

SPILL PROCEDURES

Name and telephone number of the person responsible for enforcing safe work practices with nuclear substances in this work area:

Radiation Safety Officer	Telephone number

Person in charge	Telephone number

General Precautions

1. Inform persons in the area that a spill has occurred. Keep them away from the contaminated area.
2. Cover the spill with absorbent material to prevent the spread of contamination.

Minor Spills (Typically less than 100 exemption quantities of a nuclear substance)

1. Wearing protective clothing and disposable gloves, clean up the spill using absorbent paper and place it in a plastic bag for transfer to a labelled waste container.
2. Avoid spreading contamination. Work from the outside of the spill towards the centre.
3. Wipe test or survey for residual contamination as appropriate. Repeat decontamination, if necessary, until contamination monitoring results meet the Nuclear Substances and Radiation Devices licence criteria.
4. Check hands, clothing, and shoes for contamination.
5. Report the spill and cleanup to the person in charge and, if necessary, to the Radiation Safety Officer.
6. Record spill details and contamination monitoring results. Adjust inventory and waste records appropriately.

Major Spills (Major spills involve more than 100 exemption quantities, or contamination of personnel, or release of volatile material)

1. Clear the area. Persons not involved in the spill should leave the immediate area. Limit the movement of all personnel who may be contaminated until they are monitored.
2. If the spill occurs in a laboratory, leave the fume hood running to minimize the release of volatile nuclear substances to adjacent rooms and hallways.
3. Close off and secure the spill area to prevent entry. Post warning sign(s).
4. Notify the Radiation Safety Officer or person in charge immediately.
5. The Radiation Safety Officer or person in charge will direct personnel decontamination and will decide about decay or cleanup operations.
6. In general, decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap.
7. Follow the procedures for minor spills (if appropriate).
8. Record the names of all persons involved in the spill. Note the details of any personal contamination.
9. The Radiation Safety Officer or person in charge will arrange for any necessary bioassay measurements.
10. If required, submit a written report to the Radiation Safety Officer or person in charge.
11. The Radiation Safety Officer or person in charge must submit a report to the CNSC.

Major spill procedures should be implemented whenever minor spill procedures would be inadequate.

If an exposure may have occurred that is in excess of applicable radiation dose limits, the CNSC shall be contacted within 24 hours of the occurrence under Section 16 of the Radiation Protection Regulations

For more information, contact: Directorate of Nuclear Substance Regulation, Canadian Nuclear Safety Commission, P.O. Box 1046, Station B, Ottawa, ON K1P 5S9.
Telephone: 1-888-229-2672. Fax: (613) 995-5086.

GUIDELINES FOR HANDLING PACKAGES CONTAINING NUCLEAR SUBSTANCES

Identifying Packages Containing Nuclear Substances

The packaging and labeling of nuclear substances is governed by the Canadian Nuclear Safety Commission's *Packaging and Transport of Nuclear Substances (PTNS) Regulations.* Nuclear substances may be shipped in "Excepted Packages", "Type A" or "Type B" packages, "Industrial Packages I, II, III", and packages for "Fissile Material". The "radioactive" category labels also show radiation dose rates.

On Excepted Packages, no external labeling is required, and the safety mark "RADIOACTIVE" must be visible upon opening the package. The radiation level at any point on the external surface of the package must not exceed 5 µSv/h. All other packages must be categorized by radiation level and display the corresponding radiation warning labels as follows:

Category I-WHITE
Does not exceed 5 µSv/h at any location on the external surface of the package

Category II-YELLOW
Does not exceed 500 µSv/h at any location on the external surface of the package and the transport index does not exceed 1.

Category III-YELLOW
Does not exceed 2 mSv/h at any location on the external surface of the package and the transport index does not exceed 10.

The transport index is the maximum radiation level in microsieverts per hour at one metre from the external surface of the package, divided by 10.
Example: 1 µSv/h (0.1 mrem/h) at 1 m equals a TI = 0.1.

Upon receipt of a package containing nuclear substances, keep your distance. Examine the package for damage or leakage. If the package is damaged or leaking, contain and isolate it to minimize radiation exposure and contamination, and comply with Section 19 of the PTNS *Regulations*.

Opening Packages Containing Nuclear Substances

Radiation Safety Officer	Phone Number

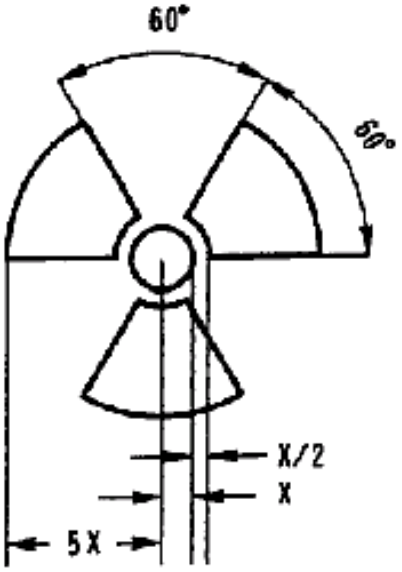
1. If an appropriate survey monitor is available, monitor the radiation fields around the package. Note any discrepancies.
2. Avoid unnecessary direct contact with unshielded containers.
3. Verify the nuclear substance, the quantity, and other details with the information on the packing slip and with the purchase order. Log the shipment details and any anomalies in the inventory record.
4. Report any anomalies (radiation levels in excess of the package labeling, incorrect transport index, contamination, leakage, short or wrong shipment) to the Radiation Safety Officer.

When opening packages containing unsealed nuclear substances, additional steps should be taken:

5. Wear protective clothing while handling the package.
6. If the material is volatile (unbound iodine, tritium, radioactive gases, etc.) or in a powder form, open the package in a fume hood.
7. Open the outer package and check for possible damage to the contents, broken seals, or discoloration of packing materials. If the contents appear to be damaged, isolate the package to prevent further contamination and notify the Radiation Safety Officer.
8. If no damage is evident, wipe test the inner package or primary container which holds the unsealed nuclear substance. If contamination is detected, monitor all packaging and, if appropriate, all locations in contact with the package, for contamination. Contain the contamination, decontaminate, and dispose in accordance with the conditions of the Nuclear Substances and Radiation Devices licence.

For more information, contact: Directorate of Nuclear Substance Regulation, Canadian Nuclear Safety Commission, P.O. Box 1046, Station B, Ottawa, ON K1P 5S9. Telephone: 1-888-229-2672. Fax: (613) 995-5086.

Radiation Warning Symbol



NOTE:
The three blades and the central disk of this symbol shall be:
(a) magenta and black
(b) located on a yellow background

NUCLEAR SAFETY AND CONTROL ACT: Radiation Protection Regulations, 31 May, 2000

Radiation Warning Sign for Laboratories

RAYONNEMENT-
DANGER-
RADIATION

24H Emergency contact: RSO through Locating 53333

Every point of access to an area, room or enclosure where there is more than 100 EQ of radioactive materials or where the radiation dose rate might exceed 25 μSv/h must be labeled with a radiation warning sign that bears the trefoil symbol and the words “RAYONNEMENT-DANGER-RADIATION”.

APPENDIX 4:

NCRC Thyroid Intercomparison Program

NCRC THYROID INTERCOMPARISON PROGRAM

The **N**ational **C**alibration **R**eference **C**entre for Bioassay and *In Vivo* Monitoring (NCRC) has specially designed neck phantoms that allow a facility to establish that the quality of their thyroid monitoring program, where necessary, meets the requirements of Regulatory Standard S-106. The phantoms, provided to participants in the NCRC's intercomparison program, can also be used to establish calibration factors.

The benefit of participation in the thyroid intercomparison program is two-fold. First, facilities can compare their results to other Canadian facilities and judge their performance based on the results. Second, and more important, the participation in the NCRC's intercomparison program allows the facility to show that their in-house calibrations are accurate and that their quality assurance program is performing as expected. The use of an outside independent standard gives any quality assurance program more credibility than it would otherwise have if all results were based on in-house data.

Each year, participants in the thyroid intercomparison program are mailed a kit that contains the following: a neck phantom modeled from a human neck made of material to closely approximate human tissue, inserts designed to mimic a real thyroid gland containing simulated ^{131}I, and/or ^{125}I, an overlay plate to allow for different thickness of tissue over the thyroid gland, instructions for the proper use of the phantom (including a training video), a report form, and a telephone "hot-line" number for assistance. The NCRC provides advice and assistance to participating facilities to solve problems identified through their participation in the thyroid intercomparison program and maintains a historical, confidential data base for efficient information retrieval and trend analysis.

The tests that can be performed with the neck-thyroid phantoms are:

- Accuracy of counting
- Determination of the **M**inimum **D**etectable **A**ctivity (MDA)
- Effect of overlaying tissue
- Precision of counting
-

Accuracy of Counting

The accuracy of counting B is obtained by evaluating the bias of the facility for any given phantom. The bias is given by the following expression:

$$B = \frac{A_i - A}{A} \times 100$$

Where:

B is the bias (expressed as a percent).

$\mathbf{A_i}$ is the observed value.

A is the true value.

The acceptable limit for bias, B(%), is that it should be greater than or equal to -25% and less than or equal to +50%. The activity in the test phantom must be greater than five times the MDA specified in Table 2 of Regulatory Standard S-106 for that nuclide. The actual activities of the inserts used and the bias results are sent to the participating facility in the form of a short report. The facility's contact person is telephoned, when necessary, to discuss remedial action that should be taken to improve the performance of their monitoring system.

Determination of the Minimum Detectable Activity

The Minimum Detectable Activity should be determined using an uncontaminated subject, and applying the following expression to the results.

$$MDA = \frac{4.65 \times \sqrt{BCKGND}}{E \times T} + \frac{3}{E \times T}$$

Where:

BCKND is the total number of counts in the region of interest for a given radionuclide.

E is the calibration factor used to convert the count rate to activity and includes geometry factors.

T is the count period, usually in seconds (assumed to be the same for sample and background).

Effect of Overlying Tissue

The facility can use the overlay plate to investigate the change in efficiency for their counting system. The change in counting efficiency will depend on detector type, detector size, counting geometry, and collimation.

Precision of Counting

Precision of counting is performed by counting the neck-thyroid phantom repeatedly. Between each count the phantom is removed and replaced in the counting position. The phantom is counted five times. Precision S is then estimated by the following expression:

$$S = \frac{100 \times \sqrt{\sum_{1}^{N} \frac{(A_i - M)}{(n - 1)}}}{M}$$

Where:

S is the precision (expressed as a percent).

$\mathbf{A_i}$ is the observed value.

M is the mean of the data set.

N is the number of measurements (usually five).

The acceptable limit for precision, (S%), is that it should be less than or equal to 40%.

Ref.: http://www.hc-sc.gc.ca/hecs-sesc/ncrc/thyroid.htm

APENDIX 5:

Internal Permit Application for Acquisition and Use of Radioactive Materials

Identification:

1. Permit Holder — Address

Last name: **Office room number:**

First name: **Office phone number:**

Title: **Cell phone number:**

Department: **Pager number:**

Email:

2. Internal Radiation Safety Designate (or Departmental Radiation Supervisor)

This person should be able to provide day-to-day supervision of the work of employees in matters of radiation safety.

Last name: **Office room number:**

First name: **Office phone number:**

Title: **Cell phone number:**

Department: **Pager number:**

Email:

3. Radioisotope User Information

Please use one sheet per worker:

Personnel Information

Last name : _____ First name: _____

Permit number : _____ Title: _____

Radiation Safety Training (Location): _____ Date: _____

TDG class 7 Training (Location): _____ Date: _____

TLD Information (please circle)

Dosimeter type: 1) Whole Body 2) Ring / Wrist 3) Other: _____

Radioisotope Information

A) Radioisotope: _____ Maximum activity used: _____

Description of use:

_____

_____

_____

B) Radioisotope: _____ Maximum activity used: _____

Description of use:

_____

_____

_____

C) Radioisotope: _____ Maximum activity used: _____

Description of use:

_____

_____

_____

4. Personnel Not Working with Radioisotopes

Please use one sheet per worker:

Personnel Information

Last name : _____ First name: _____

Permit number: _____ Title: _____

TLD Information ***(if applicable)***

Dosimeter type: 1) _____

Laboratory Information

Reason for working in laboratory:

_____

_____

5. Radiation Exposure Monitoring

Do you use TLD (Thermoluminescent Dosimetry Radiation) badges? _____

If yes, please specify which dosimeter types and related group code (look on your Radiation Exposure Report from the Radiation Protection Bureau)

Type	Group Code	No. of Visitor Badges	Visitor Badges Issued to:
☐ Whole body dosimeter			
☐ Ring dosimeter			
☐ Wrist dosimeter			
☐ Other type of dosimeter Specify: _____			
☐ No dosimeter	NA	NA	NA

Note: According to our licence condition (2578-1), any person who handles more than 50 MBq of P-32, Sr-89, Y-90, Sm-157 or Rh-185 must wear a ring dosimeter.

6. Purchases and Possession limits

Please indicate the maximum activity per stock vial for any isotope. Also indicate the maximum quantity possessed at any given time.(use extra sheets as necessary). Indicate units clearly (ex. mCi, MBq, …)

Radioisotope (Ex. H-3, P-32, P-33, S-35,…)	**Maximum Activity per stock vial**	**Possession limit** **(max. activity per stock vial x number of vials)**
1		

7. Access to Radioisotopes

What arrangements are in place to prevent access to radioisotopes from unauthorised users?

_____

_____

_____

8. Liquid Scintillation Counter/Gamma Counter

List the gamma and beta counters you have access to. If the counter has an internal source (housed in equipment), please give source type, serial number, activity and date measured.

Type of Device	Company & Model	Serial Number	Internal Source	Source Serial Number	Source Activity	Date of Activity Measured	Room Number

9. Accessible Sealed Sources Inventory

List any other sealed sources that are not permanently housed in equipment.

Radio isotope	Serial Number	Activity	Date of Activity Measured	Use	Room Number

10. Laboratory Information (use extra sheets as necessary)

List all rooms and usage. Room description can be “Radioisotope Laboratory”, “Storage room” , “Counter room” or “Other”.

- For “Radioisotope Laboratory”, please indicate the maximum activity per stock vial than can be handled at any given time (should normally correspond to column 2 of item 6 (see above).
- For “Storage room”, indicate the maximum activity to be stored at any given time.
- For “Counter room” and “Others”, indicate the maximum activity entered at any given time in the room.

In case of doubt about the room description, please contact the RPS. A room is described as a “Laboratory” only if there is “manipulation” of open wet sources.

Room number: _____ Description:_____

	P32	P33	S35	I125	H3	C14	Other ____
Radioisotope Laboratory: max. activity (mCi)							
Storage room : max. activity (mCi)							
Counter room : max. activity (mCi)							
Other* room: max activity (mCi)							

*Note: If “Other”, please give details below about the room usage:

_____

_____

Room number: _____ Description:_____

	P32	P33	S35	I125	H3	C14	Other ____
Radioisotope Laboratory: max. activity (mCi)							
Storage room : max. activity (mCi)							
Counter room : max. activity (mCi)							
Other* room: max activity (mCi)							

*Note: If “Other”, please give details below about the room usage:

_____

_____

11. Storage Areas (only those located outside rooms mentioned in section 10)

Please indicate all storage areas (fridge or freezer) that are located in a hallway where radioisotopes may be stored. Indicate the room closest to the storage unit

Fridge/Freezer 1
Room number: _____

Fridge/Freezer 2
Room number: _____

Fridge/Freezer 3
Room number: _____

12. Animal Protocol

Do you work with or plan on using radioactive materials in animals.

Yes	No

If yes, please provide a copy of the animal protocol.

13. Survey Meter Inventory

Give a list of handheld meters available to your laboratory.

Type	Company & Model	Serial Number	Probe Model	Probe Serial Number	Date last Calibration	Room Number

14. Permit Holder Signature

I certify that the information entered in this form is valid.

Signature: _____

Date: _____

CURRENT INVENTORY FORM
(Source Vials)

Permit Holder: ______________________ Permit Number: ______________________

Room	Isotope & Product	Activity (uCi)	Date Activity Measured	Initial Volume (ul)	Residual Volume (ul)	RTS Number

APPENDIX 7:

Contamination Monitoring

Approximate detection efficiencies for some common radionuclides and detectors

Radionuclide	LSC[1]	Pancake GM[2]	NaI(Tl) Meter[3]	NaI(Tl) Well[4]
H-3	20%	na[5]	na[5]	na[5]
C-14, S-35, P-33	50%	10%	na[5]	na[5]
Cr-51, Co-57, Tc-99m, I-125	30%	1%	50%	50%
P-32	100%	50%	na[5]	na[5]

LSC[1] : Liquid Scintillation Counter

PancakeGM[2] : Hand-held survey meter with pancake GM detector

NaI(Tl)[3] : Hand-held survey meter with well-type NaI(Tl) crystal

NaI(Tl)[4] : Multichannel analyzer with well-type NaI(Tl) crystal

na[5]: not applicable for this group of radionuclides

Ref.: http://www.stanford.edu/dept/EHS/prod/researchlab/radlaser/manual/radsafetymanual1.html

Contamination Monitoring using Wipe Tests and LSC

This table indicates the public area CNSC decontamination criteria (NC in CPM) for wipe tests measured in a Liquid Scintillation Counter (LSC). **The decontamination level NC is the net count rate of wipe tests (in CPM) below which a room can be opened to public.** However, it is good laboratory practice to continue decontamination procedure until the level is As Low As Reasonably Achievable (ALARA). The last column is a limit below which no additional decontamination efforts are normally required. Also indicated are the Exemption Quantities (EQ) below which a license is not required to possess, transfer or use radioisotopes (Exemption areas).

Isotope	EQ MBq	Class	LSC Nominal Efficiency (E)	Wipes Public Area Bq/cm2 (CL)	**Decontamination level in CPM* (NC)**	ALARA level of 0.5 Bq/cm2 in CPM**
C-14	10	C	0.5	30	**9000**	150
Ca-45	10	C	0.5	30	**9000**	150
Co-57	1	C	0.3	30	**5400**	90
Cr-51	10	C	0.3	30	**5400**	90
Fe-59	1	B	0.5	3	**900**	150
H-3	1000	C	0.2	30	**3600**	60
I-125	1	C	0.3	30	**5400**	90
P-32	0.1	C	1	30	**18000**	300
P-33	100	C	0.5	30	**9000**	150
Rb-86	0.1	B	1	3	**1800**	300
S-35	100	C	0.5	30	**9000**	150

*CNSC public area decontamination limit in CPM (net count rate) measured by Liquid Scintillation Counting (LSC) for various radioisotopes commonly used in laboratories.

The net count rate in CPM (background subtracted) that indicates decontamination level is reached is calculated using the following formula:

$$NC\ (CPM) = W_{eff} * E * CL * 60 * A\ ,$$

W_{eff} = Wipe efficiency (0.1 for wet wipes);
E = LSC nominal Efficiency for specific isotope;
CL = CNSC contamination level (Wipes Public Area) in Bq/cm2;
A = area wiped (100 cm2).

** ALARA limit below which no additional decontamination efforts are required (see MUHC Radiation Safety Manual/NSRD, items 6.9.11-6.9.12).

Direct Contamination Monitoring : Pancake Probe
Controlled Area

Isotope	EQ MBq	Class	Pancake Nominal Efficiency (E)	Wipes Controlled Area Bq/cm2 (CL)	**Decontamination level in CPM* (NC)**	Conversion factor Net CPM to Bq/cm2
C-14	10	C	0.03	300	**8100**	0.0370
F-18	1	A	0.1	3	**270**	0.0111
Na-22	1	A	0.1	3	**270**	0.0111
Ca-45	10	C	0.03	300	**8100**	0.0370
P-32	0.1	C	0.15	300	**40500**	0.0074
P-33	100	C	0.03	300	**8100**	0.0370
Co-58	1	B	0.03	30	**810**	0.0370
Ga-67	1	B	0.01	30	**270**	0.1111
Rb-86	0.1	B	0.15	30	**4050**	0.0074
S-35	100	C	0.03	300	**8100**	0.0370
Mo-99/Tc-99m	10	C	0.005	300	**1350**	0.2222
In-111	1	B	0.01	30	**270**	0.1111
I-123	10	C	0.005	300	**1350**	0.2222
I-131	1	B	0.11	30	**2970**	0.0101
Tl-201	1	B	0.02	30	**540**	0.0556

*Decontamination levels for radioisotope commonly used in laboratories in CPM (net counts) using an Pancake probe. The net counts (background subtracted) NC in CPM that indicates decontamination level is reached is calculated using the following formula :

NC (CPM) = E*CL*60*A

E = G-M Pancake measured Efficiency at 1 cm
CL = CNSC contamination level (Wipes Public Area) in Bq/cm2
A = area of Pancake (15 cm2)

LUDLUM 44-9 Specifications (4-pi):
C-14 : 5%
P-32 : 32%

Direct Contamination Monitoring : Pancake Probe
Public Area

Isotope	EQ MBq	Class	Pancake Nominal Efficiency (E)	Wipes Public Area Bq/cm2 (CL)	**Decontamination level in CPM* (NC)**	Conversion factor Net CPM to Bq/cm2
C-14	10	C	0.03	30	**810**	0.0370
F-18	1	A	0.1	0.3	**27**	0.0111
Na-22	1	A	0.1	0.3	**27**	0.0111
Ca-45	10	C	0.03	30	**810**	0.0370
P-32	0.1	C	0.15	30	**4050**	0.0074
P-33	100	C	0.03	30	**810**	0.0370
Co-58	1	B	0.03	3	**81**	0.0370
Ga-67	1	B	0.01	3	**27**	0.1111
Rb-86	0.1	B	0.15	3	**405**	0.0074
S-35	100	C	0.03	30	**810**	0.0370
Mo-99/Tc-99m	10	C	0.005	30	**135**	0.2222
In-111	1	B	0.01	3	**27**	0.1111
I-123	10	C	0.005	30	**135**	0.2222
I-131	1	B	0.11	3	**297**	0.0101
Tl-201	1	B	0.02	3	**54**	0.0556

*Decontamination levels for radioisotope commonly used in laboratories in CPM (net counts) using an Pancake probe. The net counts (background subtracted) NC in CPM that indicates decontamination level is reached is calculated using the following formula :

NC (CPM) = E*CL*60*A

E = G-M Pancake measured Efficiency at 1 cm
CL = CNSC contamination level (Wipes Public Area) in Bq/cm2
A = area of Pancake (15 cm2)

LUDLUM 44-9 Specifications (4-pi):
C-14 : 5%
P-32 : 32%

Direct Contamination Monitoring : NaI 44-3 Probe
Public Area

Isotope	EQ MBq	Class	Probe Nominal Efficiency (E)	Wipes Public Area Bq/cm2 (CL)	**Decontamination level in CPM* (NC)**	Conversion factor Net CPM to Bq/cm2
I-125	1	C	0.07	30	**630**	0.0476
Mo-99/Tc-99m	10	C	0.04	30	**360**	0.0833
In-111	1	B	0.04	3	**36**	0.0833

Direct Contamination Monitoring : NaI 44-3 Probe
Controlled Area

Isotope	EQ MBq	Class	Probe Nominal Efficiency (E)	Wipes Public Area Bq/cm2 (CL)	**Decontamination level in CPM* (NC)**	Conversion factor Net CPM to Bq/cm2
I-125	1	C	0.07	300	**6300**	0.0476
Mo-99/Tc-99m	10	C	0.04	300	**3600**	0.0833
In-111	1	B	0.04	30	**360**	0.0833

*Decontamination levels for radioisotope commonly used in laboratories in CPM (net counts) using an NaI probe. The net counts (background subtracted) NC in CPM that indicates decontamination level is reached is calculated using the following formula :

NC (CPM) = E*CL*60*A

E = NaI 44-3 measured Efficiency at 1 cm
CL = CNSC contamination level (Wipes Public Area) in Bq/cm2
A = area of NaI probe 44-3 (5 cm2)

LUDLUM 44-3 Specifications:
I-125 : 19% (4-pi)

CONTAMINATION CONTROL RECORD (DIRECT METHOD)

PERMIT HOLDER _____ PERMIT # _____

DEPARTMENT _____ ROOM # _____

ISOTOPES USED _____

Make and Model of Detector _____

Date: _____	BACKGROUND CPM _____

LOCATION	Net CPM	Bq/cm^2	After cleanup	COMMENTS
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Name (Print) : _____

Signature: _____

APPENDIX 8 :

Radionuclides data

Classes of Nuclear Substances:

The following table organizes a number of common nuclear substances, including those for which surface contamination and waste disposal limits are typically incorporated into CNSC licenses, into three classes –"Class A", "Class B", or "Class C" – on the basis of common radiological characteristics.

CLASS	RADIONUCLIDE				
CLASS A	All alpha emitters and their daughter isotopes			Ag-110m	Ar-41
	C-11	Co-56	Co-60	F-18	Ga-68
	Ga-72	I-124	La-140	Mn-56	N-13
	Na-22	Na-24	Nb-98	O-15	Sb-124
	Ta-182	V-48	Y-86	Zn-65	
CLASS B	As-74	Au-198	Ba-133	Br-82	Co-58
	Cu-64	Fe-59	Ga-67	Gd-153	Hg-194
	Hg-203	I-131	In-111	In-113m	In-114m
	Ir-192	K-42	Kr-79	Kr-81m	Nb-95
	Pa-233	Rb-84	Rb-86	Ru-103	Sc-46
	Se-75	Sm-153	Sn-123	Sr-85	Sr-90
	Xe-127				
CLASS C	Au-195m	C-14	Ca-45	Cd-109	Ce-141
	Ce-144	Cl-36	Co-57	Cr-51	Fe-55
	Ge-68	H-3	I-123	I-125	In-114
	Kr-85	Lu-177	Ni-63	P-32	P-33
	Re-186	Re-188	S-35	Sn-113	Sr-89
	Tc-99	Tc-99m	Tl-201	V-49	W-188
	Xe-133	Y-86	Y-90	Yb-169	

EXEMPTION QUANTITIES (Exhaustive List)

Ref: Nuclear Substances and Radiation Devices Regulations (SOR/2000-207) current to August 13th, 2008

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Actinium 227	1×10^{-1}	1×10^{3}
Actinium 228	1×10^{1}	1×10^{6}
Americium 241	1×10^{0}	1×10^{4}
Americium 242	1×10^{3}	1×10^{6}
Americium 242m[a]	1×10^{0}	1×10^{4}
Americium 243[a]	1×10^{0}	1×10^{3}
Antimony 122	1×10^{2}	1×10^{4}
Antimony 124	1×10^{1}	1×10^{6}
Antimony 125	1×10^{2}	1×10^{6}
Argon 37	1×10^{6}	1×10^{8}
Argon 41	1×10^{2}	1×10^{9}
Arsenic 73	1×10^{3}	1×10^{7}
Arsenic 74	1×10^{1}	1×10^{6}
Arsenic 76	1×10^{2}	1×10^{5}
Arsenic 77	1×10^{3}	1×10^{6}
Astatine 211	1×10^{3}	1×10^{7}
Barium 131	1×10^{2}	1×10^{6}
Barium 133	1×10^{2}	1×10^{6}
Barium 140[a]	1×10^{1}	1×10^{5}
Berkelium 249	1×10^{3}	1×10^{6}
Beryllium 7	1×10^{3}	1×10^{7}
Bismuth 206	1×10^{1}	1×10^{5}
Bismuth 207	1×10^{1}	1×10^{6}
Bismuth 210	1×10^{3}	1×10^{6}
Bismuth 212[a]	1×10^{1}	1×10^{5}
Bromine 82	1×10^{1}	1×10^{6}
Cadmium 107	1×10^{3}	1×10^{7}
Cadmium 109	1×10^{4}	1×10^{6}
Cadmium 113m	1×10^{3}	1×10^{6}
Cadmium 115	1×10^{2}	1×10^{6}
Cadmium 115m	1×10^{3}	1×10^{6}
Calcium 45	1×10^{4}	1×10^{7}
Calcium 47	1×10^{1}	1×10^{6}
Californium 246	1×10^{3}	1×10^{6}
Californium 248	1×10^{1}	1×10^{4}
Californium 249	1×10^{0}	1×10^{3}
Californium 250	1×10^{1}	1×10^{4}
Californium 251	1×10^{0}	1×10^{3}
Californium 252	1×10^{1}	1×10^{4}
Californium 253	1×10^{2}	1×10^{5}
Californium 254	1×10^{0}	1×10^{3}
Carbon 11	1×10^{1}	1×10^{6}
Carbon 14	1×10^{4}	1×10^{7}
Cerium 139	1×10^{2}	1×10^{6}

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Cerium 141	1×10^{2}	1×10^{7}
Cerium 143	1×10^{2}	1×10^{6}
Cerium 144[a]	1×10^{2}	1×10^{5}
Cesium 129	1×10^{2}	1×10^{5}
Cesium 131	1×10^{3}	1×10^{6}
Cesium 132	1×10^{1}	1×10^{5}
Cesium 134	1×10^{1}	1×10^{4}
Cesium 134m	1×10^{3}	1×10^{5}
Cesium 135	1×10^{4}	1×10^{7}
Cesium 136	1×10^{1}	1×10^{5}
Cesium 137[a]	1×10^{1}	1×10^{4}
Cesium 138	1×10^{1}	1×10^{4}
Chlorine 36	1×10^{4}	1×10^{6}
Chlorine 38	1×10^{1}	1×10^{5}
Chromium 49	1×10^{1}	1×10^{6}
Chromium 51	1×10^{3}	1×10^{7}
Cobalt 55	1×10^{1}	1×10^{6}
Cobalt 56	1×10^{1}	1×10^{5}
Cobalt 57	1×10^{2}	1×10^{6}
Cobalt 58	1×10^{1}	1×10^{6}
Cobalt 58m	1×10^{4}	1×10^{7}
Cobalt 60	1×10^{1}	1×10^{5}
Cobalt 60m	1×10^{3}	1×10^{6}
Cobalt 61	1×10^{2}	1×10^{6}
Cobalt 62m	1×10^{1}	1×10^{5}
Copper 60	1×10^{1}	1×10^{5}
Copper 64	1×10^{2}	1×10^{6}
Copper 67	1×10^{2}	1×10^{6}
Curium 242	1×10^{2}	1×10^{5}
Curium 243	1×10^{0}	1×10^{4}
Curium 244	1×10^{1}	1×10^{4}
Curium 245	1×10^{0}	1×10^{3}
Curium 246	1×10^{0}	1×10^{3}
Curium 247	1×10^{0}	1×10^{4}
Curium 248	1×10^{0}	1×10^{3}
Dysprosium 159	1×10^{3}	1×10^{7}
Dysprosium 165	1×10^{3}	1×10^{6}
Dysprosium 166	1×10^{3}	1×10^{6}
Einsteinium 253	1×10^{2}	1×10^{5}
Einsteinium 254	1×10^{1}	1×10^{4}
Einsteinium 254m	1×10^{2}	1×10^{6}
Erbium 169	1×10^{4}	1×10^{7}
Erbium 171	1×10^{2}	1×10^{6}
Europium 152	1×10^{1}	1×10^{6}
Europium 152m	1×10^{2}	1×10^{6}
Europium 154	1×10^{1}	1×10^{6}
Europium 155	1×10^{2}	1×10^{7}
Fermium 254	1×10^{4}	1×10^{7}
Fermium 255	1×10^{3}	1×10^{6}
Fluorine 18	1×10^{1}	1×10^{6}
Gadolinium 153	1×10^{2}	1×10^{7}

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Gadolinium 159	1×10^{3}	1×10^{6}
Gallium 67	1×10^{2}	1×10^{6}
Gallium 72	1×10^{1}	1×10^{5}
Germanium 68	1×10^{1}	1×10^{5}
Germanium 71	1×10^{4}	1×10^{8}
Gold 195	1×10^{2}	1×10^{7}
Gold 198	1×10^{2}	1×10^{6}
Gold 199	1×10^{2}	1×10^{6}
Hafnium 181	1×10^{1}	1×10^{6}
Holmium 166	1×10^{3}	1×10^{5}
Hydrogen 3	1×10^{6}	1×10^{9}
Indium 111	1×10^{2}	1×10^{6}
Indium 113m	1×10^{2}	1×10^{6}
Indium 114m	1×10^{2}	1×10^{6}
Indium 115	1×10^{3}	1×10^{5}
Indium 115m	1×10^{2}	1×10^{6}
Iodine 123	1×10^{2}	1×10^{7}
Iodine 125	1×10^{3}	1×10^{6}
Iodine 126	1×10^{2}	1×10^{6}
Iodine 129	1×10^{2}	1×10^{5}
Iodine 130	1×10^{1}	1×10^{6}
Iodine 131	1×10^{2}	1×10^{6}
Iodine 132	1×10^{1}	1×10^{5}
Iodine 133	1×10^{1}	1×10^{6}
Iodine 134	1×10^{1}	1×10^{5}
Iodine 135	1×10^{1}	1×10^{6}
Iridium 190	1×10^{1}	1×10^{6}
Iridium 192	1×10^{1}	1×10^{4}
Iridium 194	1×10^{2}	1×10^{5}
Iron 52	1×10^{1}	1×10^{6}
Iron 55	1×10^{4}	1×10^{6}
Iron 59	1×10^{1}	1×10^{6}
Krypton 74	1×10^{2}	1×10^{9}
Krypton 76	1×10^{2}	1×10^{9}
Krypton 77	1×10^{2}	1×10^{9}
Krypton 79	1×10^{3}	1×10^{5}
Krypton 81	1×10^{4}	1×10^{7}
Krypton 83m	1×10^{5}	1×10^{12}
Krypton 85	1×10^{5}	1×10^{4}
Krypton 85m	1×10^{3}	1×10^{10}
Krypton 87	1×10^{2}	1×10^{9}
Krypton 88	1×10^{2}	1×10^{9}
Lanthanum 140	1×10^{1}	1×10^{5}
Lead 203	1×10^{2}	1×10^{6}
Lead 210[a]	1×10^{1}	1×10^{4}
Lead 212[a]	1×10^{1}	1×10^{5}
Lutetium 177	1×10^{3}	1×10^{7}
Manganese 51	1×10^{1}	1×10^{5}
Manganese 52	1×10^{1}	1×10^{5}
Manganese 52m	1×10^{1}	1×10^{5}
Manganese 53	1×10^{4}	1×10^{9}

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Manganese 54	1×10^{1}	1×10^{6}
Manganese 56	1×10^{1}	1×10^{5}
Mercury 197	1×10^{2}	1×10^{7}
Mercury 197m	1×10^{2}	1×10^{6}
Mercury 203	1×10^{2}	1×10^{5}
Molybdenum 90	1×10^{1}	1×10^{6}
Molybdenum 93	1×10^{3}	1×10^{8}
Molybdenum 99	1×10^{2}	1×10^{6}
Molybdenum 101	1×10^{1}	1×10^{6}
Neodymium 147	1×10^{2}	1×10^{6}
Neodymium 149	1×10^{2}	1×10^{6}
Neptunium 237[a]	1×10^{0}	1×10^{3}
Neptunium 239	1×10^{2}	1×10^{7}
Neptunium 240	1×10^{1}	1×10^{6}
Nickel 59	1×10^{4}	1×10^{8}
Nickel 63	1×10^{5}	1×10^{8}
Nickel 65	1×10^{1}	1×10^{6}
Niobium 93m	1×10^{4}	1×10^{7}
Niobium 94	1×10^{1}	1×10^{6}
Niobium 95	1×10^{1}	1×10^{6}
Niobium 97	1×10^{1}	1×10^{6}
Niobium 98	1×10^{1}	1×10^{5}
Nitrogen 13	1×10^{2}	1×10^{9}
Osmium 185	1×10^{1}	1×10^{6}
Osmium 191	1×10^{2}	1×10^{7}
Osmium 191m	1×10^{3}	1×10^{7}
Osmium 193	1×10^{2}	1×10^{6}
Oxygen 15	1×10^{2}	1×10^{9}
Palladium 103	1×10^{3}	1×10^{8}
Palladium 109	1×10^{3}	1×10^{6}
Phosphorous 32	1×10^{3}	1×10^{5}
Phosphorous 33	1×10^{5}	1×10^{8}
Platinum 191	1×10^{2}	1×10^{6}
Platinum 193m	1×10^{3}	1×10^{7}
Platinum 197	1×10^{3}	1×10^{6}
Platinum 197m	1×10^{2}	1×10^{6}
Plutonium 234	1×10^{2}	1×10^{7}
Plutonium 235	1×10^{2}	1×10^{7}
Plutonium 236	1×10^{1}	1×10^{4}
Plutonium 237	1×10^{3}	1×10^{7}
Plutonium 238	1×10^{0}	1×10^{4}
Plutonium 239	1×10^{0}	1×10^{4}
Plutonium 240	1×10^{0}	1×10^{3}
Plutonium 241	1×10^{2}	1×10^{5}
Plutonium 242	1×10^{0}	1×10^{4}
Plutonium 243	1×10^{3}	1×10^{7}
Plutonium 244	1×10^{0}	1×10^{4}
Polonium 203	1×10^{1}	1×10^{6}
Polonium 205	1×10^{1}	1×10^{6}
Polonium 207	1×10^{1}	1×10^{6}
Polonium 210	1×10^{1}	1×10^{4}

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Potassium 40	1×10^{2}	1×10^{6}
Potassium 42	1×10^{2}	1×10^{6}
Potassium 43	1×10^{1}	1×10^{6}
Praseodymium 142	1×10^{2}	1×10^{5}
Praseodymium 143	1×10^{4}	1×10^{6}
Promethium 147	1×10^{4}	1×10^{7}
Promethium 149	1×10^{3}	1×10^{6}
Protactinium 230	1×10^{1}	1×10^{6}
Protactinium 231	1×10^{0}	1×10^{3}
Protactinium 233	1×10^{2}	1×10^{7}
Radium 223[a]	1×10^{2}	1×10^{5}
Radium 224[a]	1×10^{1}	1×10^{5}
Radium 225	1×10^{2}	1×10^{5}
Radium 226[a]	1×10^{1}	1×10^{4}
Radium 227	1×10^{2}	1×10^{6}
Radium 228[a]	1×10^{1}	1×10^{5}
Radon 220[a]	1×10^{4}	1×10^{7}
Radon 222[a]	1×10^{1}	1×10^{8}
Rhenium 186	1×10^{3}	1×10^{6}
Rhenium 187	1×10^{6}	1×10^{9}
Rhenium 188	1×10^{2}	1×10^{5}
Rhodium 103m	1×10^{4}	1×10^{8}
Rhodium 105	1×10^{2}	1×10^{7}
Rubidium 86	1×10^{2}	1×10^{5}
Ruthenium 97	1×10^{2}	1×10^{7}
Ruthenium 103	1×10^{2}	1×10^{6}
Ruthenium 105	1×10^{1}	1×10^{6}
Ruthenium 106[a]	1×10^{2}	1×10^{5}
Samarium 151	1×10^{4}	1×10^{8}
Samarium 153	1×10^{2}	1×10^{6}
Scandium 46	1×10^{1}	1×10^{6}
Scandium 47	1×10^{2}	1×10^{6}
Scandium 48	1×10^{1}	1×10^{5}
Selenium 75	1×10^{2}	1×10^{6}
Selenium 79	1×10^{4}	1×10^{7}
Silicon 31	1×10^{3}	1×10^{6}
Silver 105	1×10^{2}	1×10^{6}
Silver 110m	1×10^{1}	1×10^{6}
Silver 111	1×10^{3}	1×10^{6}
Sodium 22	1×10^{1}	1×10^{6}
Sodium 24	1×10^{1}	1×10^{5}
Strontium 85	1×10^{2}	1×10^{6}
Strontium 85m	1×10^{2}	1×10^{7}
Strontium 87m	1×10^{2}	1×10^{6}
Strontium 89	1×10^{3}	1×10^{6}
Strontium 90[a]	1×10^{2}	1×10^{4}
Strontium 91	1×10^{1}	1×10^{5}
Strontium 92	1×10^{1}	1×10^{6}
Sulphur 35	1×10^{5}	1×10^{8}
Tantalum 182	1×10^{1}	1×10^{4}
Technetium 96	1×10^{1}	1×10^{6}

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Technetium 96m	1×10^{3}	1×10^{7}
Technetium 97	1×10^{3}	1×10^{8}
Technetium 97m	1×10^{3}	1×10^{7}
Technetium 99	1×10^{4}	1×10^{7}
Technetium 99m	1×10^{2}	1×10^{7}
Tellurium 123m	1×10^{2}	1×10^{7}
Tellurium 125m	1×10^{3}	1×10^{7}
Tellurium 127	1×10^{3}	1×10^{6}
Tellurium 127m	1×10^{3}	1×10^{7}
Tellurium 129	1×10^{2}	1×10^{6}
Tellurium 129m	1×10^{3}	1×10^{6}
Tellurium 131	1×10^{2}	1×10^{5}
Tellurium 131m	1×10^{1}	1×10^{6}
Tellurium 132	1×10^{2}	1×10^{7}
Tellurium 133	1×10^{1}	1×10^{5}
Tellurium 133m	1×10^{1}	1×10^{5}
Tellurium 134	1×10^{1}	1×10^{6}
Terbium 160	1×10^{1}	1×10^{6}
Thallium 200	1×10^{1}	1×10^{6}
Thallium 201	1×10^{2}	1×10^{6}
Thallium 202	1×10^{2}	1×10^{6}
Thallium 204	1×10^{4}	1×10^{4}
Thorium 226[a]	1×10^{3}	1×10^{7}
Thorium 227	1×10^{1}	1×10^{4}
Thorium 228[a]	1×10^{0}	1×10^{4}
Thorium 229[a]	1×10^{0}	1×10^{3}
Thorium 230	1×10^{0}	1×10^{4}
Thorium 231	1×10^{3}	1×10^{7}
Thorium 232	1×10^{1}	1×10^{4}
Thorium 234[a]	1×10^{3}	1×10^{5}
Thorium natural[a]	1×10^{0}	1×10^{3}
Thulium 170	1×10^{3}	1×10^{6}
Thulium 171	1×10^{4}	1×10^{8}
Tin 113	1×10^{3}	1×10^{7}
Tin 125	1×10^{2}	1×10^{5}
Tungsten 181	1×10^{3}	1×10^{7}
Tungsten 185	1×10^{4}	1×10^{7}
Tungsten 187	1×10^{2}	1×10^{6}
Uranium 230[a]	1×10^{1}	1×10^{5}
Uranium 231	1×10^{2}	1×10^{7}
Uranium 232[a]	1×10^{0}	1×10^{3}
Uranium 233	1×10^{1}	1×10^{4}
Uranium 234	1×10^{1}	1×10^{4}
Uranium 235[a]	1×10^{1}	1×10^{4}
Uranium 236	1×10^{1}	1×10^{4}
Uranium 237	1×10^{2}	1×10^{6}
Uranium 238[a]	1×10^{1}	1×10^{4}
Uranium 239	1×10^{2}	1×10^{6}
Uranium 240	1×10^{3}	1×10^{7}
Uranium 240[a]	1×10^{1}	1×10^{6}
Uranium natural[a]	1×10^{0}	1×10^{3}

Column 1 Radioactive Nuclear Substance	Column 2 Activity Concentration (Bq/g)	Column 3 Activity (Bq)
Vanadium 48	1×10^{1}	1×10^{5}
Xenon 123	1×10^{2}	1×10^{9}
Xenon 129m	1×10^{3}	1×10^{4}
Xenon 131m	1×10^{4}	1×10^{4}
Xenon 133	1×10^{3}	1×10^{4}
Xenon 135	1×10^{3}	1×10^{10}
Ytterbium 169	1×10^{2}	1×10^{7}
Ytterbium 175	1×10^{3}	1×10^{7}
Yttrium 90	1×10^{3}	1×10^{5}
Yttrium 91	1×10^{3}	1×10^{6}
Yttrium 91m	1×10^{2}	1×10^{6}
Yttrium 92	1×10^{2}	1×10^{5}
Yttrium 93	1×10^{2}	1×10^{5}
Zinc 65	1×10^{1}	1×10^{6}
Zinc 69	1×10^{4}	1×10^{6}
Zinc 69m	1×10^{2}	1×10^{6}
Zirconium 93[a]	1×10^{3}	1×10^{7}
Zirconium 95	1×10^{1}	1×10^{6}
Zirconium 97[a]	1×10^{1}	1×10^{5}

Appendix A
Dose Conversion Factors (DCF) and Annual Limits on Intake (ALI) for Common Nuclear Substances

Table A1: DCF and ALI Values for Common Nuclear Substances
[Source: DCFs from ICRP-68[2] and NRPB-W22[3]; ALIs derived from DCFs (ALI = 20 mSv/DCF)]

Note: ALIs listed are for a particle size (Activity Median Aerodynamic Diameter, AMAD) of 5 μm. The solubility selected from ICRP-68 was that which results in the lowest ALI for each listed radionuclide and intake route (inhalation or ingestion).

Nuclear Substance	DCF (Sv/Bq) Inhalation	ALI (Bq) Inhalation	DCF (Sv/Bq) Ingestion	ALI (Bq) Ingestion
Actinium 227 (^{227}Ac)	6.3×10^{-04}	3.2×10^{01}	1.1×10^{-06}	1.8×10^{04}
Aluminum 26 (^{26}Al)	1.4×10^{-08}	1.4×10^{06}	3.5×10^{-09}	6.0×10^{06}
Americium 241 (^{241}Am)	2.7×10^{-05}	7.4×10^{02}	2.0×10^{-07}	1.0×10^{05}
Antimony 124 (^{124}Sb)	4.7×10^{-09}	4.3×10^{06}	2.5×10^{-09}	8.0×10^{06}
Arsenic 74 (^{74}As)	1.8×10^{-09}	1.1×10^{07}	1.3×10^{-09}	1.5×10^{07}
Barium 133 (^{133}Ba)	1.8×10^{-09}	1.1×10^{07}	1.0×10^{-09}	2.0×10^{07}
Barium 140 (^{140}Ba)	1.6×10^{-09}	1.3×10^{07}	2.5×10^{-09}	8.0×10^{06}
Beryllium 7 (^{7}Be)	4.6×10^{-11}	4.3×10^{08}	2.8×10^{-11}	7.1×10^{08}
Beryllium 10 (^{10}Be)	1.9×10^{-09}	1.1×10^{06}	1.1×10^{-09}	1.8×10^{07}
Bismuth 207 (^{207}Bi)	3.2×10^{-09}	6.3×10^{06}	1.3×10^{-09}	1.5×10^{07}
Bismuth 210 (^{210}Bi)	6.0×10^{-08}	3.3×10^{05}	1.3×10^{-09}	1.5×10^{07}
Bromine 82 (^{82}Br)	8.8×10^{-10}	2.3×10^{07}	5.4×10^{-10}	3.7×10^{07}
Cadmium 109 (^{109}Cd)	9.6×10^{-09}	2.1×10^{06}	2.0×10^{-09}	1.0×10^{07}
Calcium 45 (^{45}Ca)	2.3×10^{-09}	8.7×10^{06}	7.6×10^{-10}	2.6×10^{07}
Californium 252 (^{252}Cf)	1.3×10^{-05}	1.5×10^{03}	9.0×10^{-08}	2.2×10^{05}
Carbon 11 (^{11}C)	2.2×10^{-12}	9.1×10^{09}	2.4×10^{-11}	8.3×10^{08}
Carbon 14 * (^{14}C)	2.0×10^{-11}	1.0×10^{09}	5.8×10^{-10}	3.4×10^{07}
Cerium 141 (^{141}Ce)	3.1×10^{-08}	6.5×10^{06}	7.1×10^{-10}	2.8×10^{07}
Cerium 144 (^{144}Ce)	2.9×10^{-08}	6.9×10^{05}	5.2×10^{-09}	3.8×10^{06}
Cesium 134 (^{134}Cs)	9.6×10^{-09}	2.1×10^{06}	1.9×10^{-08}	1.1×10^{06}
Cesium 137 (^{137}Cs)	6.7×10^{-09}	3.0×10^{06}	1.3×10^{-08}	1.5×10^{06}
Chlorine 36 (^{36}Cl)	5.1×10^{-09}	3.9×10^{06}	9.3×10^{-10}	2.2×10^{07}
Chromium 51 (^{51}Cr)	3.6×10^{-11}	5.6×10^{08}	3.8×10^{-11}	5.3×10^{08}
Cobalt 57 (^{57}Co)	6.0×10^{-10}	3.3×10^{07}	2.1×10^{-10}	9.5×10^{07}
Cobalt 58 (^{58}Co)	1.7×10^{-09}	1.2×10^{07}	7.4×10^{-10}	2.7×10^{07}
Cobalt 60 (^{60}Co)	1.7×10^{-08}	1.2×10^{06}	3.4×10^{-09}	5.9×10^{06}
Copper 64 (^{64}Cu)	1.5×10^{-10}	1.3×10^{08}	1.2×10^{-10}	1.7×10^{08}
Copper 67 (^{67}Cu)	5.8×10^{-10}	3.4×10^{07}	3.4×10^{-10}	5.9×10^{07}
Curium 244 (^{244}Cm)	1.7×10^{-05}	1.2×10^{03}	1.2×10^{-07}	1.7×10^{05}
Fluorine 18 (^{18}F)	9.3×10^{-11}	2.2×10^{08}	4.9×10^{-11}	4.1×10^{08}
Gadolinium 153 (^{153}Gd)	2.5×10^{-09}	8.0×10^{06}	2.7×10^{-10}	7.4×10^{07}
Gallium 67 (^{67}Ga)	2.8×10^{-10}	7.1×10^{07}	1.9×10^{-10}	1.1×10^{08}
Gallium 68 (^{68}Ga)	8.1×10^{-11}	2.5×10^{08}	1.0×10^{-10}	2.0×10^{08}

Nuclear Substance	DCF (Sv/Bq) Inhalation	ALI (Bq) Inhalation	DCF (Sv/Bq) Ingestion	ALI (Bq) Ingestion
Germanium 68 (^{68}Ge)	7.9×10^{-09}	2.5×10^{06}	1.3×10^{-09}	1.5×10^{07}
Gold 198 (^{198}Au)	1.1×10^{-09}	1.8×10^{07}	1.0×10^{-09}	2.0×10^{07}
Hydrogen 3 (HT) (^{3}H)	2.0×10^{-15}	1.0×10^{13}	---	---
Hydrogen 3 (HTO) ** (^{3}H)	2.0×10^{-11}	1.0×10^{09}	2.0×10^{-11}	1.0×10^{09}
Hydrogen 3 (OBT) † (^{3}H)	4.1×10^{-11}	4.9×10^{08}	4.2×10^{-11}	4.8×10^{08}
Indium 111 (^{111}In)	3.1×10^{-10}	6.5×10^{07}	2.9×10^{-10}	6.9×10^{07}
Indium 113m (^{113m}In)	3.2×10^{-11}	6.3×10^{08}	2.8×10^{-11}	7.1×10^{08}
Indium 114m (^{114m}In)	1.1×10^{-08}	1.8×10^{06}	4.1×10^{-09}	4.9×10^{06}
Iodine 123 (^{123}I)	2.1×10^{-10}	9.5×10^{07}	2.1×10^{-10}	9.5×10^{07}
Iodine 124 (^{124}I)	1.2×10^{-08}	1.7×10^{06}	1.3×10^{-08}	1.5×10^{06}
Iodine 125 (^{125}I)	1.4×10^{-08}	1.4×10^{06}	1.5×10^{-08}	1.3×10^{06}
Iodine 129 (^{129}I)	9.6×10^{-08}	2.1×10^{05}	1.1×10^{-07}	1.8×10^{05}
Iodine 131 (^{131}I)	2.0×10^{-08}	1.0×10^{06}	2.2×10^{-08}	9.1×10^{05}
Iodine 132 (^{132}I)	3.1×10^{-10}	6.5×10^{07}	2.9×10^{-10}	6.9×10^{07}
Iridium 192 (^{192}Ir)	4.9×10^{-09}	4.1×10^{06}	1.4×10^{-09}	1.4×10^{07}
Iron 55 (^{55}Fe)	9.2×10^{-10}	2.2×10^{07}	3.3×10^{-10}	6.1×10^{07}
Iron 59 (^{59}Fe)	3.2×10^{-09}	6.3×10^{06}	1.8×10^{-09}	1.1×10^{07}
Krypton 85 (gas) Bq/m^3 ‡ (^{85}Kr)	2.2×10^{-11}	9.1×10^{08}	---	---
Lanthanum 140 (^{140}La)	1.5×10^{-09}	1.3×10^{07}	2.0×10^{-09}	1.0×10^{07}
Lead 210 (^{210}Pb)	1.1×10^{-06}	1.8×10^{04}	6.8×10^{-07}	2.9×10^{04}
Magnesium 28 (^{28}Mg)	1.7×10^{-09}	1.2×10^{07}	2.2×10^{-09}	9.0×10^{06}
Manganese 54 (^{54}Mn)	1.2×10^{-09}	1.7×10^{07}	7.1×10^{-10}	2.8×10^{07}
Manganese 56 (^{56}Mn)	2.0×10^{-10}	1.0×10^{08}	2.5×10^{-10}	8.0×10^{07}
Mercury 194 (organic) (^{194}Hg)	1.9×10^{-08}	1.1×10^{06}	5.1×10^{-08}	3.9×10^{05}
Mercury 197 (organic) (^{197}Hg)	8.5×10^{-11}	2.4×10^{08}	1.7×10^{-10}	1.2×10^{08}
Mercury 197 (inorganic) (^{197}Hg)	2.8×10^{-10}	7.1×10^{07}	2.3×10^{-10}	8.7×10^{07}
Mercury 203 (organic) (^{203}Hg)	7.5×10^{-10}	2.7×10^{07}	1.9×10^{-09}	1.1×10^{07}
Mercury 203 (inorganic) (^{203}Hg)	1.9×10^{-09}	1.1×10^{07}	5.4×10^{-10}	3.7×10^{07}
Molybdenum 99 (^{99}Mo)	1.1×10^{-09}	1.8×10^{07}	1.2×10^{-09}	1.7×10^{07}
Nickel 63 (^{63}Ni)	5.2×10^{-10}	3.8×10^{07}	1.5×10^{-10}	1.3×10^{08}
Niobium 95 (^{95}Nb)	1.3×10^{-09}	1.5×10^{07}	5.8×10^{-10}	3.4×10^{07}
Phosphorus 32 (^{32}P)	2.9×10^{-09}	6.9×10^{06}	2.4×10^{-09}	8.3×10^{06}
Phosphorus 33 (^{33}P)	1.3×10^{-09}	1.5×10^{07}	2.4×10^{-10}	8.3×10^{07}
Plutonium 239 (^{239}Pu)	3.2×10^{-05}	6.3×10^{02}	2.5×10^{-07}	8.0×10^{04}
Plutonium 240 (^{240}Pu)	3.2×10^{-05}	6.3×10^{02}	2.5×10^{-07}	8.0×10^{04}
Polonium 209 (^{209}Po)	2.3×10^{-06}	8.8×10^{03}	3.0×10^{-07}	6.6×10^{04}
Polonium 210 (^{210}Po)	2.2×10^{-06}	9.1×10^{03}	2.4×10^{-07}	8.3×10^{04}
Potassium 42 (^{42}K)	2.0×10^{-10}	1.0×10^{08}	4.3×10^{-10}	4.7×10^{07}
Promethium 147 (^{147}Pm)	3.5×10^{-09}	5.7×10^{06}	2.6×10^{-10}	7.7×10^{07}
Protactinium 233 (^{233}Pa)	3.2×10^{-09}	6.3×10^{06}	8.7×10^{-10}	2.3×10^{07}
Radium 223 (^{223}Ra)	5.7×10^{-06}	3.5×10^{03}	1.0×10^{-07}	2.0×10^{05}
Radium 226 (^{226}Ra)	2.2×10^{-06}	9.1×10^{03}	2.8×10^{-07}	7.1×10^{04}
Rhenium 186 (^{186}Re)	1.2×10^{-09}	1.7×10^{07}	1.5×10^{-09}	1.3×10^{07}

Nuclear Substance	DCF (Sv/Bq) Inhalation	ALI (Bq) Inhalation	DCF (Sv/Bq) Ingestion	ALI (Bq) Ingestion
Rhenium 188 (^{188}Re)	7.4×10^{-10}	2.7×10^{07}	1.4×10^{-09}	1.4×10^{07}
Rubidium 86 (^{86}Rb)	1.3×10^{-09}	1.5×10^{07}	2.8×10^{-09}	7.1×10^{06}
Ruthenium 103 (^{103}Ru)	2.2×10^{-09}	9.1×10^{06}	7.3×10^{-10}	2.7×10^{07}
Scandium 46 (^{46}Sc)	4.8×10^{-09}	4.2×10^{06}	1.5×10^{-09}	1.3×10^{07}
Selenium 75 (^{75}Se)	1.7×10^{-09}	1.2×10^{07}	2.6×10^{-09}	7.7×10^{06}
Silicon 31 (^{31}Si)	1.1×10^{-10}	1.8×10^{08}	1.6×10^{-10}	1.3×10^{08}
Silicon 32 (^{32}Si)	5.5×10^{-08}	3.6×10^{05}	5.6×10^{-10}	3.5×10^{07}
Silver 110m (^{110m}Ag)	7.3×10^{-09}	2.7×10^{06}	2.8×10^{-09}	7.1×10^{06}
Sodium 22 (^{22}Na)	2.0×10^{-09}	1.0×10^{07}	3.2×10^{-09}	6.3×10^{06}
Sodium 24 (^{24}Na)	5.3×10^{-10}	3.8×10^{07}	4.3×10^{-10}	4.7×10^{07}
Strontium 85 (^{85}Sr)	6.4×10^{-10}	3.1×10^{07}	5.6×10^{-10}	3.6×10^{07}
Strontium 89 (^{89}Sr)	5.6×10^{-09}	3.6×10^{06}	2.6×10^{-09}	7.7×10^{06}
Strontium 90 (^{90}Sr)	7.7×10^{-08}	2.6×10^{05}	2.8×10^{-08}	7.1×10^{05}
Sulphur 35 (inorganic) (^{35}S)	1.1×10^{-09}	1.8×10^{07}	1.9×10^{-10}	1.1×10^{08}
Sulphur 35 (organic v) (^{35}S)	1.2×10^{-10}	1.7×10^{08}	7.7×10^{-10}	2.6×10^{07}
Technetium 99m (^{99m}Tc)	2.9×10^{-11}	6.9×10^{08}	2.2×10^{-11}	9.1×10^{08}
Technetium 99 (^{99}Tc)	3.2×10^{-09}	6.3×10^{06}	7.8×10^{-10}	2.6×10^{07}
Thallium 201 (^{201}Tl)	7.6×10^{-11}	2.6×10^{08}	9.5×10^{-11}	2.1×10^{08}
Thallium 204 (^{204}Tl)	6.2×10^{-10}	3.2×10^{07}	1.3×10^{-09}	1.5×10^{07}
Thorium 228 (^{228}Th)	3.2×10^{-05}	6.3×10^{02}	6.9×10^{-08}	2.9×10^{05}
Thorium 229 (^{229}Th)	6.9×10^{-05}	2.9×10^{02}	4.8×10^{-07}	4.2×10^{04}
Thorium 230 (^{230}Th)	2.8×10^{-05}	7.1×10^{02}	2.1×10^{-07}	9.5×10^{04}
Tin 113 (^{113}Sn)	1.9×10^{-09}	1.1×10^{07}	7.3×10^{-10}	2.7×10^{07}
Uranium (natural) ††	6.3×10^{-06}	3.2×10^{03}	9.5×10^{-09}	2.1×10^{06}
Uranium (depleted) ††	5.9×10^{-06}	3.4×10^{03}	1.1×10^{-08}	1.9×10^{06}
Uranium 232 (^{232}U) ††	2.6×10^{-05}	7.7×10^{02}	3.3×10^{-07}	6.1×10^{04}
Uranium 233 (^{233}U) ††	6.9×10^{-06}	2.9×10^{03}	5.0×10^{-08}	4.0×10^{05}
Uranium 235 (^{235}U) ††	6.1×10^{-06}	3.3×10^{03}	4.6×10^{-08}	4.3×10^{05}
Uranium 236 (^{236}U) ††	6.3×10^{-06}	3.2×10^{03}	4.6×10^{-08}	4.3×10^{05}
Uranium 238 (^{238}U) ††	5.7×10^{-06}	3.5×10^{03}	4.4×10^{-08}	4.5×10^{05}
Xenon 133 (gas) Bq/cm^3 ‡ (^{133}Xe)	1.2×10^{-10}	6.7×10^{05}	---	---
Xenon 135 (gas) Bq/cm^3 ‡ (^{135}Xe)	9.6×10^{-10}	8.3×10^{04}	---	---
Yttrium 87 (^{87}Y)	5.3×10^{-10}	3.8×10^{07}	5.5×10^{-10}	3.6×10^{07}
Yttrium 90 (^{90}Y)	1.7×10^{-09}	1.2×10^{07}	2.7×10^{-09}	7.4×10^{06}
Zinc 65 (^{65}Zn)	2.8×10^{-09}	7.1×10^{06}	3.9×10^{-09}	5.1×10^{06}

* CO_2 value from ICRP-based data published from 1955-1970. New data (1990-2000) and revision of the model (2004) recommend higher dose coefficient. Revised $^{14}CO_2$ dose coefficient from Leggett, R.W., Radiation Protection Dosimetry Vol. 208, pp. 203-213 (2004).

** Hydrogenated Tritium Oxide (HTO), also referred to as "tritiated water"
ICRP DCF is 1.8E-11; value used here is from Health Canada 83-EHD-87 (1983) and RSP-182B (2004).

† Organically Bound Tritium (OBT)

‡ The concentration equivalent of 20 mSv per year (assuming 250 working days and 8-hour workday).

†† Type S (slow), insoluble compounds

Appendix R: Regulatory Quantities for Typical Radionuclides

Radionuclide	EQ MBq	ALI Estimate (Inhalation) Bq	ALI Estimate (Ingestion) Bq	Basic Level MBq	Interim Level MBq	High Level MBq	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Br-82	1	2.30E+07	3.70E+07	115	1150	11,500	3	0.3			
C-14	10	1.00E+09	3.40E+07	170	1,700	17,000	300	30	3.7	10,000	
Co-57	1	3.30E+07	9.50E+07	165	1650	16,500	300	30	0.37	1,000	
Co-58	1	1.20E+07	2.70E+07	60	600	6,000	30	3	0.37	100	
Co-60	0.1	1.20+E06	5.90+E06	6	60	600	3	0.3	0.01	0.1	
Cr-51	10	5.60E+08	5.30E+08	2,650	26,500	265,000	300	30	3.7	100	
F-18	1	2.20E+08	4.10E+08	1100	11,000	110,000	3	0.3	0.01	0.1	
Fe-59	1	6.30E+06	1.10E+07	31.5	315	3,150	30	3	0.01	1	
Ga-67	1	7.10E+07	1.10E+08	355	3550	35,500	30	3	0.037	100	
H-3	1,000	1.00E+09	1.00E+09	5,000	50,000	500,000	300	30	37	1,000,000	37
I-123	10	9.50E+07	9.50E+07	475	4,750	47,500	300	30	3.7	1,000	3
I-125	1	1.40E+06	1.30E+06	6.5	65	650	300	30	0.037	100	0.03
I-131	1	1.00E+06	9.10E+05	4.55	45.5	455	30	3	0.037	10	0.175
In-111	1	6.50E+07	6.90E+07	325	3,250	32,500	30	3	0.037	100	
Na-22	1	1.00E+07	6.30E+06	31.5	315	3,150	3	0.3	0.01	0.1	
P-32	0.1	6.90E+06	8.30E+06	34.5	345	3,450	300	30	0.37	1	
P-33	100	1.50E+07	8.30E+07	75	750	7,500	300	30	1	10	
Ra-226	0.01	9.10E+03	7.10E+04	0.0455	0.455	4.55	3	0.3	0.0037	1	
S-35	100	1.80E+07	2.6E+.07	90	900	9,000	300	30	0.37	1,000	
Sb-124	1	4.30E+06	8.00E+06	21.5	215	2,150	3	0.3	0.37	0.1	
Sr-85	1	3.10E+07	3.60E+07	155	1,550	15,500	30	3	0.1	1	0.175
Tc-99m	10	6.90E+08	9.10E+08	3450	34,500	345,000	300	30	3.7	1,000	
Tl-201	1	2.60E+08	2.10E+07	105	1,050	10,500	300	30	0.037	100	
Xe-133	0.01	6.70E+05		3.35	33.5	335	300	30			3.7

APPENDIX 9:

Decommissioning Report

DECOMMISSIONING REPORT

Permit Holder: _____ Internal Permit: _____ Room #:_____

Part A: To be completed by the Permit Holder

1) Confirm that all radioactive materials have been properly disposed of. This includes source vials, by-products and waste (liquid, solid, and LSV). YES NO

2) Please identify **all** areas and equipment used for radioactive work in this lab. A written list and a map are required. Please attach the documents to this form. YES NO

3) Were any drains used for radioactive work (e.g. disposal)? YES NO

4) Were any fume hoods used? YES NO

5) Confirm that all items/areas which may have been used for radioactive work have been:
   a) direct monitored (specify instrument and probe): _____ YES NO
   b) wipe tested. (Please attach results to this form) YES NO

6) Confirm that all radiation warning labels have been removed from work areas and equipment. Do not remove door sign, lab classification posters and permit. YES NO

I certify that the information entered in this form is valid.

Signature: _____ Title: _____ Date:_____

Part B: To be completed by the Radiation Protection Service

1) Checked survey results. YES NO

2) Removal of warning signs verified. YES NO

3) Comments:

_____

_____

_____

4) Door signs, lab classification posters and permit removed. YES NO

5) Permit removed from RPS database. Date removed: _____ YES NO

Signature: _____ Title: _____ Date: _____

APPENDIX 10:

McGill Radioisotope Tracking System (MyLAB)

How to track the Use of a Radioisotope in the McGill Radioisotope Tracking System

1. Log on the McGill MyLAB site at:
   https://mylab.mcgill.ca/EHSAWeb/EHSAWebISAPI.dll/EXEC

2. Enter your User ID and Password (contact the RSO for creating a new account).

3. Upon receipt of a new vial, create a new vial record. Enter a unique identification number for the vial, e.g. the PO number, as well as the relevant data such as reference date, isotope, etc. **Each** vial, including those already in storage, must be entered into the computer.

4. Create radioactive waste containers electronically that will be used for the disposal of radioactive waste. The computer will generate a waste container number. Mark this number on the designated waste container before using. Separate containers must be provided for:

   - Solid radioactive waste (one isotope per container)
   - Liquid radioactive waste (one isotope per container)
   - Liquid scintillation vials
   - Empty stock vials

   With the exception of liquid scintillation vials, radioactive waste containers cannot be shared between permit holders at this time.

5. As the vial is used, record the amount of activity removed from the vial using the "vial use reports".

6. When radioactive material is not disposed of immediately, record the use as by-product.

7. Whenever a new product (by-product or secondary product) is made from an original vial, this new product must be labelled with the radioisotope, date, activity and name of the individual responsible for the item using the label shown below.

8. Remove or deface all markings prior to disposal in the radioactive waste container.

9. When more than one radioisotope is required to be disposed of at one time, e.g. for dual labelling experiments where it is not possible to segregate isotopes, then each radioisotope should be entered into the inventory program separately and two radioactive waste containers created electronically. The number of each of the

generated waste containers and the isotope and activity for each isotope should be written on the one waste container that is actually used to dispose of the combined radioisotope waste.

10. Tracking of LSV waste is not required on the computer unless a large percentage (e.g. more than 1%) of the activity of the vial has been disposed of in LSV. In this case, select LSV as the disposal container. Normally a total activity of the LSV container is adequate for labelling of the LSV container.

11. All radioisotope tracking forms (both electronic and paper form) should be completed with the user's first initial and full last name; a user's initials or nickname are not considered adequate identification by the Canadian Nuclear Safety Commission.

12. An online training video on how to use the tracking software MyLAB is available at: http://knowledgebase.mcgill.ca/display/2/articleDirect/index.asp?aid=9640&r=0.2002985

Radioisotope Inventory Sheet (1 vial or byproduct per sheet)

Location	Source	Shipment
Lab:	**Isotope:**	**Supplier:**
Supervisor:	**Product:**	**ID number:**
Contact person:	**Activity:**	**Received:**
	Volume:	
	Ref. date:	

Date of use	User (full name)	Procedure	Quantity used	Quantity left in vial	Waste Form	Disposal Method	Comments

Waste Form			Disposal Method		
L	=	Aqueous Liquid	1	=	Transferred to Waste Management .
S	=	Solid	2	=	Store + Decay + Municipal Garbage
B	=	Biohazard /infectious	3	=	Store + Decay + Sewer
A	=	Animal Carcass	4	=	Store + Decay + Biohazard waste (waste form A & B)
			5	=	Return to supplier
			6	=	Transfer to another lab

Note: If a byproduct is created, refer to byproduct sheet ID number in comments

APPENDIX 11:

Laboratory Inspection Sheet

Permit Number: _____ Permit Holder: _____

MUHC Laboratories Inspection Form	Yes	No	N/A
1- Signs and Labels			
CNSC Posters displayed (Room classification, Spill, Pkg. Handling) ?			
24-h Emergency contact info displayed?			
Radiation Warning Signs on all doors?			
Radiation Warning Signs on storage areas?			
Work Areas Labeled?			
2- Internal Permit Information			
Internal Permit displayed?			
Internal Permit current/accurate?			
3- Control of radioisotopes			
Are radioisotopes properly secured from non-authorized users?			
Are inventory records available/accurate?			
Was there any unauthorized transfer of radioisotopes?			
4- Contamination Monitoring			
Is contamination monitoring performed/documented every 7 days?			
Locations identified on a wipe test map?			
Records in good order?			
Is decontamination being conducted when required?			
Is follow-up contamination being recorded?			
5- Handling Practices			
Is there evidence for food, drink, smoking?			
Are lab coats and gloves being worn?			
Are work areas covered with absorbent pads?			
Are staff wearing TLDs when required?			
Is shielding being used when required?			
Is work conducted in fume-hood when required?			
6-Intrumentation			
Are correct instruments provided?			
Are instruments functioning and in good condition?			
Have survey meters been calibrated during the past 12 months?			

Radiation Survey Reading at storage area (μSv/h): _____

Comments: _____

_____

Date : _____ RSO signature : _____

Gammacell Inspection Form	Yes	No	N/A
1- Signs and Labels			
Radiation warning sign posted on door?			
24-h Emergency contact info displayed?			
2- CNSC Permit Information			
CNSC Permit displayed in room?			
CNSC Permit current/accurate?			
3- Security			
Is the Gammacell accessible only to authorized users?			
Security lock in good condition?			
Motion detector operational?			
Double bias door switch operational?			
Security system connected to 24H security desk?			
4- Leak test			
Annual leak test indicated source not leaking?			
Last Leak test done during the past 12 months (date: _____) ?			
5-Intrumentation			
Survey meter available (model: _____; serial: _____) ?			
Survey meter in good condition?			
Have survey meters been calibrated during the past 12 months?			

Radiation Survey (done by RSO):

Make/Model/SN of survey meter used: _____
Dose rate at 1 meter from the Gammacell (μSv/h): _____
Dose rate at 5 cm from the Gammacell sample chamber (μSv/h): _____

Comments: _____

_____

_____

Date : _____ RSO signature : _____

Site : _____ Room: _____ Classification: _____

MUHC Nuclear Medicine Rooms Inspection Form	Yes	No	N/A
1- Signs and Labels			
CNSC Posters displayed (Room classification, Spill, Pkg. Handling)?			
24-h Emergency contact info displayed?			
Radiation Warning Signs on doors for rooms with more than 100 EQ?			
2- Control of radioisotopes			
Are radioisotopes properly secured from non-authorized users?			
Are inventory records available/accurate?			
3- Contamination Monitoring			
Is contamination monitoring done every 7 days or after each use?			
Locations monitored identified on a map?			
Records in good order?			
Is decontamination being conducted when required?			
Is follow-up contamination being recorded?			
4- Handling Practices			
Is there evidence for food, drink, smoking?			
Are lab coats and gloves being worn?			
Are work areas covered with absorbent pads?			
Are staff wearing dosimeters as required?			
Is shielding being used when required?			
Is work conducted in fume-hood when required?			
5-Intrumentation			
Are correct instruments provided?			
Are instruments functioning and in good condition?			
Have survey meters been calibrated during the past 12 months?			

Radiation Survey (to be measured by RSO during visit):
Max. dose rate at storage area (μSv/h): _____
Max. dose rate in occupied areas around storage (μSv/h): _____

Contamination level below CNSC limits for Isotopes in use (Y/N): _____
(Attach results from contamination survey)

Comments: _____

_____

_____

(Continue on reverse if necessary)

Date : _____ RSO signature : _____

APPENDIX 12: Tc-99m Forms for Contamination Monitoring and Waste Disposal

Montreal Neurological Institute and Hospital

A Teaching and Research Institute at McGill University

CONTAMINATION CONTROL RECORD (DIRECT METHOD)

DEPARTMENT _____ ROOM # _____

ISOTOPES USED _____

Make and Model of Detector _____

Date:	BKG (CPM):

Location (description)	NET CPM before cleanup	CPM after cleanup (if necessary)	PASS * (check if ok)	Comments

* For Tc-99m, PASS level (using a pancake probe) is less than:

1350 CPM above background (Controlled Areas) or
135 CPM above background (Public Areas)

Name : _____

Sign: _____

Montreal Neurological Institute and Hospital

A Teaching and Research Institute at McGill University

Tc-99m Biohazard Waste Disposal records

Room: _____

Make and Model of Detector _____

Tc-99m Biohazard Date of disposal	BKG (CPM)	CONTAINER (CPM) *	Signature	Comments

* Container must be at BKG level before disposal to biohazard waste

Montreal Neurological Institute and Hospital

A Teaching and Research Institute at McGill University

Tc-99m Excepted Package Contamination Monitoring

Room: _____ ; Make and Model of Detector _____

Date of return (YYYY-MM-DD)	BKG (CPM)	PACKAGE (CPM) *	Signature	Comments

* Package must be less than 36 CPM above BKG (pancake probe) before shipment.

Method:

1 Use a wet wipe (paper or tissue).
2 Wipe an area of about 300 cm2 over the outside surface of the package.
3 Count the wipe using a pancake probe in a low BKG area.
4 Record the readings.
5 If reading is below 36 CPM above BKG, package may be offered for transport.
6 If reading is greater than 36 CPM above BKG, decontaminate or store for decay and repeat 1.

APPENDIX 13:

Emergency Measures

RADIATION

Ionizing radiation cannot be detected by the senses. Trained personnel with appropriate detection instruments are required to evaluate potential exposures, and assist in decontamination procedure (if required)

RADIOACTIVE SPILL:
Follow the Procedure for **Code Brown**
Rescue the employees / **Isolate** the room. (See Note 1)
Try to control the spill if it can be done in a secure manner. (See Note 2)

MALFUNCTION OF A RADIATION EMITTING DEVICE:
Cut power to the device and **evacuate** the room. (See Note 3)
Prevent access to the room and post a notice on the door preventing entrance.
Call 55555 to advise the Radiation Safety Officer.

INJURY WITH POSSIBILITY OF RADIOACTIVE CONTAMINATION:
1- Treat serious physical traumas. (See Note 4)
2- Decontaminate the patient as soon as possible after his condition has been stabilized.
3- Advise the Radiation Safety Officer (Through locating if needed).

LOSS OR THEFT OF RADIOACTIVE MATERIAL:
1- Report the incident to the Radiation Safety Officer.
The lost or theft of greater than 1 exemption quantity (EQ) of radioactive material must be reported to the Canadian Nuclear Safety Commission (CNSC) within 24 hours (or as soon as possible).

DISCOVERY OF A RADIOACTIVE MATERIAL OR PACKAGE:
1- Call Security and the Radiation Safety Officer.

Additional informations:

1 Only the personnel with the appropriate training may inspect and clean radioactive material.

2 If it can be done in a secure manner.
Mesures to be taken for contaminated personnel:
- Remove clothing and shoes.
- Flush the skin with lukewarm water and mild soap.

3 The Canadian Nuclear Safety Commission (CNSC) will be advised by the Radiation Safety Officer within 24 hours following the incident. A written report will be supplied to the CNSC as well as to the Hospital Occupational Health and Safety Department.

4 There are three main categories of radiation sources.

- Sealed or encapsulated.
Designed and periodically evaluated to ensure their integrity, should remain intact for most accident conditions. May pose a significant external exposure hazard, but only under extreme accident conditions.

- Unsealed.
Solid (powder), liquid or gaseous state. Much lower activities than those above, but more easily dispersed into the environment than are seal sources. Contamination by, and ingestion or inhalation of, unsealed sources must therefore be considered in accidents involving unsealed sources.

- Machine Produces Radiation.
The equipment is not radioactive, it requires electricity to produce radiation, and does not render anything radioactive (most equipments). Radiation emergencies involving this equipment usually involves a limited number of individuals.

5 **Accidents involving sealed radioisotopes.**
In radiotherapy with external beams, the machine may fail to switch off at the end of the required irradiation period or (in the case of cobalt unit) the cobalt source may fail to return to the OFF position. These situations are recognizable either by the status indicated by the machine or by the continued operation of the visual scatter radiation monitor when the technician enters the room. The procedure in this situation is:
- The technician presses the "Emergency OFF" button to shut the machine down completely. However, if a cobalt source is stuck on the "ON" button, it will remain so even after emergency shut down.
- The patient must be removed from the beam, and from the room, as quickly as possible. The technician must take care not to expose himself to the direct beam during this operation.
- The room is closed and barred.
- The Radiation Safety Officer and the physicist on duty in the Department of Radiation Oncology must be informed as soon as possible.
- It is the physicist's responsibility to apply Emergency procedures.
- The Radiation Safety Officer investigates and records the incident, and reports to the Radiation Safety Committee.

- Non sealed sources are located in Nuclear Medicine (D5) in clnical labs and in research. Sealed hight activity sources are located in radiotherapy and medical imaging.

Reference notes.

Note 1 **Rescue the employees / Isolate the area:**
- Remove the victim from the radiation area.
- Provide first aid.
- If needed, control the fire according to the appropriate procedure.
- Prevent access to the room.

If the spill occurs in a laboratory, leave the fume hood running to minimize the release of volatile radioactive materials to adjacent rooms and hallways.

Note 2 **Try to control the spill**:
- Wear disposable gloves and a lab coat, or disposable coveralls.
- Establish a protection line around the contaminated area.
- Cover the spill with a small blanket, a small cushion or any absorbant tissue, from the outside of the spill toward the center.
- For powder material: cover with a wet blanket.
- Place the spill and the absorbing material in a plastic bag for transfer to radioactive waste container.
- Limit the departure of any involved employee until they are examined.
- Adjust inventory and waste records appropriately.

Note 3 **Evacuation.**
Keep a safe distance of 10 meters from the equipment.

Note 4 **Patient Care**
Treating personnel must observe all elementary precautions and treatment principles stated in the Atomic Energy Commission Board Group of Medical Advisors document "GMA-3 - Guidelines on Hospital Emergency Plans for the Management of Minor Radiation Accidents".

Code brown:
Internal spill or release of hazardous materials

Call 55555
Department responsible: Occupational Health and Safety (OH&S)
Definition

Code brown is used to alert MUHC personnel of an internal hazardous spill of chemical and pharmaceutical products, radioisotopes and biohazardous materials, as well as gas leak

In the event of a chemical spill, the individual(s) who caused the spill or the first individual who noticed the spill or leak is responsible for prompt and proper communication with other occupants, his/her immediate supervisor, and locating

2. General Instruction

When you call 55555 for every emergency situation, make sure that you can provide as much information as possible for instance building, room number, exact location of the spill, name of the product spilled or leak and any other description of the situation which may help to asses the risk. If possible try keep the Material Safety Data Sheet handy for emergency personnel

In case of spill of hazardous materials, MUHC personnel may assess the situation based on inherent toxicity of the materials, availability of personal protection equipment, training, ventilation and other relevant factors. The employees then may initiate cleaning the spill if they are certain that there will be no risk of exposure or injury. Otherwise, the employees are strongly advised to wait for Occupational Health and Safety.

An overexposure or a personal contamination only is not defined as a code Brown emergency. Please contact the Department of Occupational Health and Safety. In case of serious personal exposure seek medical attention by calling code medical 2-3.

Procedure 1

Pull fire alarm and Call 55555 Code brown or if necessary code red or code blue
Remove all occupants out of the danger to your best of capability and inform your immediate supervisor
Do not touch the spilled materials. Evacuate the area
Provide as much information as possible to locating such as room number, name of the spilled product, amount, exact location of spill
Do not engage in any clean up
Remain available if possible
If you are exposed, get fresh air, remove contaminated clothing, seek medical attention
Do not reenter area until instructed to do so by OH&S
Fill up an accident/incident report have it signed by your manager and sent it to OH&S

Procedure 2

Call 55555 code brown
Do not hide it, advise all occupants and your supervisor
get the Material Safety Data Sheet and leave the spill or leak area to a safe area, but remain available if possible**
Provide as much information as possible to locating such as room number, spilled area, name of product amount spilled etc
Do not ask housekeepers to clean up the spill
Wait for security agent and OH&S on Call, do not engage in any clean up
Get fresh air remove contaminated clothing, flush your eyes and skin if necessary
Do not enter to spill area until OH&S confirms that decontamination is complete and normal activity can resume
Fill up an accident/incident report have it signed by your manager and send it to OH&S

** If you think that your body or your clothing is contaminated with radioisotopes, please follow the procedure for radioisotope spills at the end of this document

4. Spill of Radioisotopes (Code Brown)

Scenario 1:
There is an actual or immediate potential for a fire or explosion in an area where radioactive materials are present.

What to do: Follow Procedure #1

Scenario 2:
Radioactive material has been spilled on the floor and/or on the counter

What to do:

Spills are classified as Minor (less than 100 exemption quantities) or Major (100 exemption quantities or more). Many laboratory workers manipulate only very small quantities of radioisotopes that are below one exemption quantity (1 EQ). In this situation, the procedures for Minor spill should be followed at all times. Decontamination procedures for Minor and Major spills are as follows:

- Immediately inform persons in the area that a spill has occurred.
- Keep them away from the contaminated area.
- Cover the spill with absorbent material to prevent spread of contamination.
- Estimate the quantity of radioactive material involved in the spill.
- Follow the procedure for either **Minor** or **Major** spill below.
- Only qualified workers authorized to work with radioisotopes can proceed with the decontamination procedures.

Minor spill (Minor spill typically involve less than 100 Exemption Quantities)
Routine procedure should be followed for clean up. **There is no need to call code brown**.
Qualified workers authorized to work with radioisotopes should be able to proceed with the decontamination procedures without any further assistance. Decontamination procedures are described in the CNSC document INFO-0743 posted in the laboratories (see also item 12.3.1 and Appendix 2 of the MUHC Radiation Safety Manual/NSRD).

1. Wearing protective clothing and disposable gloves, clean up the spill using absorbent paper and place in plastic bags for disposal.
2. Wipe test or survey for contamination. Repeat decontamination if necessary until contamination monitoring results meet the licence criteria.
3. Check hands, clothing and shoes for contamination.
4. Report the spill and cleanup to person in charge or the RSO if necessary.
5. Record spill details and contamination monitoring results. Adjust inventory and waste records.

Major Spill (Major spills involve more than 100 Exemption Quantities, or contamination of personnel, or release of volatile material)

Note: If the spill is well contained over a working area (e.g. workbench or fume hood) and can be cleaned up easily, it is not necessary to initiate a code brown. However, if the spill has spread over a large area (e.g. floor, hallways, ...) and poses a risk to workers or members of the public, initiate a Code Brown (call 55555). The RSO will be contacted via the 24-H on call emergency number (53333) and security will be called in immediately to help and secure the area.

Always follow the major spill procedure described in the CNSC document INFO-0743 posted in the laboratories.

1. Clear the area. Limit movement of all personnel who may be contaminated until they are monitored.
2. Leave fume hood running in the laboratory (if applicable).
3. Close off and secure the spill area (post warning signs).
4. Notify the RSO or the person in charge immediately.
5. The RSO or person in charge will direct personnel decontamination and will decide about decay or cleanup operations.
6. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap (do not use abrasive techniques like scratching).
7. Follow the procedures for minor spill (if appropriate).

8. Record the names of all persons involved in the spill and details of contamination.
9. The RSO or person in charge will arrange for bioassay measurements if necessary.
10. Submit a written report to the RSO or person in charge.
11. The RSO must submit a report to the CNSC.

Major spill procedures should be implemented whenever Minor spill procedures would be inadequate for spills of more than 1 EQ.

Notice: An overexposure or personal contamination only is not defined as a code brown emergency. In this case, contact the radiation protection service 24h emergency personnel via locating (53333) immediately.
* remove contaminated clothing
* rinse contaminated area with lukewarm water and soap
* do not use abrasive techniques like scratching
* close eyes, nose and mouth if rinsing face.

Code red - Fire

Anyone discovering a fire, or witnessing an explosion, has the responsability and authority to take whatever measures necessary to protect lives and property. This responsability is transferred to a superior or Fire Marshall upon arrival at the scene.

1 Upon discovery of a fire or smoke:

Pull the fire alarm and advise your colleagues. (See the fire alarm and advise your colleagues. (See Note 2)
Remove all persons from the danger area. Do not enter danger zone alone. (See Note 1
Close all doors and windows. (See Note 3)
Fight the fire with available equipment. (See Note 3)
Call 55555. If there is no answer, call (9) 9-1-1 directly.

2 Upon the announcement of a code red in another area than yours:

1- Return to your working area.
2- Do not call the Switchboard or Security
3- Do not use elevators.
4- Listen to voice announcements.
5- Prepare to evacuate and wait for voice directions.
6- Clear fire exits, close doors and windows.
7- Secure offices, stores, valuables, etc.
8- Turn off electrical and gas appliances, but not lights.
9- Be ready to assist affected areas, if directed.
10- Return patient charts to the Nursing station.
11- On a Care Unit, visitors are asked to evacuate immediately.

Additional information:

1 **Oxygen.**
DO NOT TURN OFF the main oxygen supply valves located in the corridors unless instructed by the Nurse in Charge or the Nursing Resource Manager.

2 **Assistance.**
If the fire is in a patient's room, pull the alarm bell in the bathroom, to obtain assistance from other employees.

3 **Lighting.**
Turn the lights on in the room to allow the emergency teams to move around easily in the affected area.

4 **Oxygen and Survival Equipment.** (respirators, anaesthesia equipment, oxygen masks, etc.)
The Fire Brigade (Red Team) will do their best to provide all necessary services, however, it could be necessary to close certain installations such as oxygen and medical gas, etc. without notice. Consequently, life equipment support operators (doctors, nurses, respiratory technicians, etc) should, at all times, remain on alert as soon as the fire alarms are activated.

5 **Radiation**
If radioactive material is present, the response team must be equipped with a Self Contained Breathing Apparatus.

6 **Move in the smoke**.
If you have to move in the smoke, crawl on the floor. The safest breathing area is located no more than 18 inches above the floor.

7 **Operating Rooms**.
When a code red is transmitted:
- Advise the Chief Surgeon and the Chief Anaesthetist of the fire location.
- No new surgery should be started.
- Evaluate the current state of each undergoing surgery.
- Prepare all personnel to ensure the operation of essential equipment in the event of an electrical power shutdown.

8 **Parking**
Ensure that all vehicules parked around the various buildings of the complex will not hinder fire fighting or resue operations. Vehicules should be towed away if needed.

- **Self Contained Breathing Apparatus**
  The hospital has six Self Contained Breathing Apparatus' situated in the following areas:
  - Two respirators in the 1st basement, near the Pine elevators, next to Room Cs1 109;
  - Two respirators on the 6th floor, near the guard desk, facing Room E6 107.5;
  - Two respirators on the main floor, Livingston Hall, Room Ls1 404.
- **Fire Fighting Equipment**
  The is a cart containing special emergency equipment on the 6th floor Cedar near the guard desk and on the 1st basement near Pine elevators. It includes:
  - two complete firemen suits (jackets, helmets, boots, gloves);
  - spare hoses;
  - spare compressed air tanks for Self Contained Breathing Apparatus;
  - spot light;
  - fire blanket.
- **Emergency Tool Box**.
  Emergency tool boxes are situated on every floor in the stairwell. Es.3 on Pine, near the elevators, Es.7 Cedar, and Es.10 near the elevators in Livingston Hall. The boxes contain: a) one pick hell fire axe; b) one crowbar; c) one nylon rope.
- **Portable alarm - Combustible Gas and Oxygen**.
  The combustible gas sensor designated to measure combustible gas or vapour and oxygen in the air and is located at the guard desk, Room D6 108.
  This apparatus is explosion proof and can be used in any type of environment.
  This apparatus is to be used BEFORE entering an area where there is a danger in order to determine the level of danger and the type of personal protective equipment to be used during the intervention.
- **Portable Smoke Gas Ejector.**
  The portable smoke and gas ejector is used whenever smoke, gas or vapors need to be ejected outside the building or when fresh air is required.
  It is equipped with a 20 foot length of 18 inch diameter flexible hose.
  This equipment is explosion proof and can be used in any type of environment.

This equipment is located on the fire cart in the room facing E6 107.5.

- **Fire Alarm System.**
  Fire Alarm Panels are located in the following area:
  - Pine Avenue entrance for Wings A, B, C.
  - Guard Desk (D6) for Wings D, E, F, G, J and S;
  - L6 for Wings L and R;

  All alarms are transmitted and printed to the folowing areas:
  - Locating (Switchboard Area) (Cs1 228);
  - Guard Desk (D6).

  *** Alarms for Wings F, G, J and S are received only at the Guard Desk.
  *** The main panel controlling the fire alarm system is situated at Locating (Switchboard Area) (Cs1 228).
  The red fire phones situated at various locations on all floors are to be used only for emergencies. These telephones automatically ring at Locating (Switchboard area).
  The activation of a fire alarm will, besides signal the alarm:
  - automatically close the fire doors in the affected area;
  - automatically unlock emergency exits in the affected area.
- **Fire hoses**
  Fire hoses are located throughout the complex, except for wings: F, G, J, K and S.
- **Alarm Bells.**
  The activation of a manual alarm sends a signal to the central surveillance area, and in some cases, will activate the alarm bells. The combined action of the manual alarm with a fire detector or the action of two detectors, or two manual stations will, however, always cause the alarm bells to ring.
- **Pressurisation**
  Some staircases will become pressurized with the sounding of the alarm. Compressed air will be fed from the top to the ground floor and doors, which will automatically open, must not be forced closed.

  Some elevator shafts may also become pressurized. The elevators will descend to the ground floor, the doors will open and the elevators will shut down until an attendant can operate them manually.
- **Building Services**
  - Ensure that the ventilating system is shut down when required.
  - Check booster pump for water pressure to fire water supply.
  - Standby in the boiler room for special instructions as required by the Fire Prevention Department to shut down main gas lines, medical gases, exhaust system or to activate the emergency power generators.

Reference notes:

Note 1 **Remove people from danger.**
If the attempt to extinguish the small fire fails or if the size of the fire is such that the life of the occupants is in immediate danger or if smoke could create a problem, an immediate evacuation is to be made.

- Evacuate the room(s).
- Check bathrooms, cupboards and under beds to make sure no one is hiding or lying unconscious.
- Shut off and remove oxygen cylinders from the area.

Note 2 **Activate the alarm.**
Pull or have someone else pull a manual fire alarm located near the closest stairwell.

People from the Neuro will skip step 3 (Call 555) and go directly to step 4.

Note 3

Contain the fire.

- Close doors and windows. Do not lock the doors.
- Assure that fire doors leading to stairwells and corridors are closed..
- Turn off all electrical equipment, except lights. If it is life support equipment (respirator, IV pump, cardiac monitor, dialysis equipment, etc), check if the equipment is battery powered. If not, manual support should be provided whenever possible.
- Fight the fire with available equipment.

Fight the fire.

If the fire is minor and controllable, try to extinguish it. 5555 must still be advised even if it has been extinguished.

Unless it is completely safe, do not return to the scene of the fire after having evacuated. After evacuation, only the Fire Marshall can authorize the personnel to return to evacuated areas.

Fire Fighting Equipment.

Do not use the fire equipment and hoses without knowing how.

Extinguishers.

Extinguishers are installed throughout the complex. Everyone should familiarize with the exact location of the extinguishers and how to use them before an emergency situation occurs. The appropriate extinguisher must be used according to the type of fire.
Class A = Inflammable solids (wood, paper, fabric, etc.);
Class B = Inflammables liquids (fuel, oil, solvents, paint, etc.);
Class C = Electrical equipment or installations.

APPENDIX 15:

Glossary and Units

GLOSSARY OF TERMS

ABSORBED DOSE:
The energy imparted by ionizing radiation per unit mass of irradiated material.

ACTIVITY:
The rate of decay (disintegrations/time) of a given amount of radioactive material.

ALARA:
An acronym for As Low As Reasonably Achievable. The principal that radiation doses should be kept as low as reasonably achievable taking into account economic and social factors.

ALPHA PARTICLE (α):
A strongly ionizing particle emitted from the nucleus during radioactive decay which is equivalent to a helium nucleus (2 protons and 2 neutrons).

ANNIHILATION RADIATION:
The two 511 keV photons produced when a positron combines with an electron resulting in the annihilation of the two particles.

ANNUAL LIMIT ON INTAKE (ALI):
The activity, in Bq, of a radionuclide that will deliver an effective dose of 20 mSv during the 50-year period after the radionuclide is taken into the body of a person 18 years old or older or during the period beginning at intake and ending at the age of 70 after it is taken into the body of a person less than 18 years old

BACKGROUND RADIATION:
Ionizing radiation arising from sources other than the one directly under consideration. Background radiation due to cosmic rays and the natural radioactivity of materials in the earth and building materials is always present.

BECQUEREL (Bq):
The SI unit of activity equal to one disintegration per second. (1 Bq = 2.7E-11 CI).

BETA PARTICLE (β):
A charged particle emitted from the nucleus of an atom, having a mass equal to that of the electron, and a single positive or negative charge.

BIOLOGICAL HALF-LIFE:
The time required for the body to eliminate by biological processes one-half of the amount of a substance which has entered it.

BREMSSTRAHLUNG:
X-rays produced by the deceleration of charged particles passing through matter.

CONTAMINATION:
The deposition of radioactive material in any place where it is not desired, particularly in any place where its presence may be harmful.

CURIE (CI):
The unit of activity equal to 3.7×10^{10} disintegrations per second.

DOSE:
A general term denoting the quantity of radiation or energy absorbed in a specified mass. The unit is the Gy (= 1 J/Kg).

EFFECTIVE DOSE:
Quantity obtained by multiplying the equivalent dose to various tissues and organs by the risk weighting factor appropriate to each, and summing the products. The unit of effective dose is sievert (Sv).

EFFECTIVE HALF-LIFE:
Time required for a radioactive nuclide in the body to be diminished fifty percent as a result of the combined action of radioactive decay and biological elimination.

EQUIVALENT DOSE:
Product of absorbed dose and factors that take into account the biological effects of the particular type of radiation. For x-rays the modifying factor is equal to 1, therefore an absorbed dose of 1 Gy results in a dose-equivalent of 1 Sv.

EXEMPTION QUANTITY (EQ):
Quantity of a nuclear substance or activity of a source below which a person may carry on activities (possess, transfer, import, export, ..) without a licence.

EXPOSURE:
A measure of the ionizations produced in air by x-ray or gamma radiation. The roentgen (R) is the traditional unit of measurement for exposure, the charge produced in air by gamma or x-rays. The SI unit of exposure is coulombs per kilogram (C/kg) of air.
(1 C/kg = 3876 R ; 1 R = 2.58E-4 C/kg)

FILM BADGE:
A packet of photographic film in a holder used for the approximate measurement of radiation dose.

GAMMA:
Electromagnetic radiation (photon) of nuclear origin.

GEIGER-MUELLER (G-M) COUNTER:
A radiation detection and measurement instrument.

GRAY (Gy):
The SI unit of absorbed dose equal to 1 Joule/kilogram.

HALF VALUE LAYER:
The thickness of any specified material necessary to reduce the intensity of an x-ray or gamma ray beam to one-half its original value.

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

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

IONIZATION CHAMBER:
A radiation detection and measurement instrument.

IONIZING RADIATION:
Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, by interaction with matter.

ISOTOPES:
Nuclides having the same number of protons in the nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in mass number. Almost identical chemical properties exist among isotopes of a particular element.

LABELED COMPOUND:
A compound consisting, in part, of radioactive nuclides for the purpose of following the compound or its fragments through physical, chemical, or biological processes.

NUCLIDE:
An of atom characterized by its mass number, atomic number, and energy state of its nucleus.

OCCUPANCY FACTOR:
Estimated fraction depending on the proportion of the irradiated time that an area is occupied, averaged over a year.

POSITRON:
A particle having a mass equal to that of an electron and a charge equal to that of an electron, but positive.

RAD:
The unit of absorbed dose equal to 100 erg/gram (or 0.01 Joule/kilogram).

RADIATION:
Energy propagated through space or a material medium.

RADIOACTIVE DECAY:
Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles, neutrons, and/or photons.

RADIOACTIVE HALF-LIFE:
The time required for a radioactive substance to lose fifty percent of its activity by decay.

RADIOACTIVITY:
The property of certain nuclides of spontaneously disintegrating and emitting radiation.

RADIONUCLIDE:
An unstable (radioactive) nuclide.

RADIOTOXICITY:
The potential of a radioactive material to cause damage to living tissue by radiation after introduction into the body.

REM:
The unit of dose equivalent equal to the absorbed dose in rad multiplied by any necessary modifying factors.

ROENTGEN (R):
The unit of radiation exposure in air equal to 2.58E-4 coulombs/kilogram.

SCINTILLATION COUNTER:
A radiation detection and measurement instrument in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.

SEALED SOURCE
"A radioactive nuclear substance in a sealed capsule or in a cover to which the substance is bonded, where the capsule or cover is strong enough to prevent contact with or the dispersion of the substance under the conditions for which the capsule or cover is designed." *Nuclear Substances and Radiation Devices Regulations (SOR/2000-207)*

SHALLOW-DOSE EQUIVALENT:
The dose equivalent at a tissue depth of 0.007 cm from external exposure of the skin or an extremity.

SIEVERT (Sv):
The SI unit of dose equivalent equal to 1 Joule/kilogram.

SPECIFIC ACTIVITY:
Total activity of a given radionuclide per unit mass or volume.

SYSTEME INTERNATIONAL (SI):
A system of units adopted by the 11th General Conference on Weights and Measurements in 1960 and used in most countries of the world.

THERMOLUMINESCENT DOSIMETER (TLD):
A dosimeter made of a crystalline material which is capable of both storing energy from absorption of ionizing radiation and releasing this energy in the form of visible light when heated. The amount of light released can be used as a measure of absorbed dose.

WEIGHTING FACTOR:
The proportion of the risk of stochastic effects for an organ or tissue when the whole body is irradiated uniformly.

X-RAY:
Electromagnetic radiation (photon) of non-nuclear origin having a wavelength shorter than that of visible light.

Measurement Units Conversion Table

Système International (SI) Units *1 Bq = 1 disintegration/second

The rad (rad) is replaced by the gray (Gy)

1 kilorad (krad)	=	10 grays (Gy)
1 rad (rad)	=	10 milligrays (mGy)
1 millirad (mrad)	=	10 micrograys (μGy)
1 microrad (μrad)	=	10 nanograys (nGy)

The gray (Gy) replaces the rad (rad)

1 gray (Gy)	=	100 rad (rad)
1 milligray (mGy)	=	100 millirad (mrad)
1 microgray (μGy)	=	100 microrad (μrad)
1 nanogray (nGy)	=	100 nanorad (nrad)

The rem (rem) is replaced by the sievert (Sv)

1 kilorem (krem)	=	10 sieverts (Sv)
1 rem (rem)	=	10 millisieverts (mSv)
1 millirem (mrem)	=	10 microsieverts (μSv)
1 microrem (μrem)	=	10 nanosieverts (nSv)

The sievert (Sv) replaces the rem (rem)

1 sievert (Sv)	=	100 rem (rem)
1 millisievert (mSv)	=	100 millirem (mrem)
1 microsievert (μSv)	=	100 microrem (μrem)
1 nanosievert (nSv)	=	100 nanorem (nrem)

The curie (Ci) is replaced by the becquerel (Bq)*

1 kilocurie (kCi)	=	37 terabecquerels (TBq)
1 curie (Ci)	=	37 gigabecquerels (GBq)
1 millicurie (mCi)	=	37 megabecquerels (MBq)
1 microcurie (μCi)	=	37 kilobecquerels (kBq)
1 nanocurie (nCi)	=	37 becquerels (Bq)

The becquerel (Bq)* replaces the curie (Ci)

1 terabecquerel (TBq)	=	27 curies (Ci)
1 gigabecquerel (GBq)	=	27 millicuries (mCi)
1 megabecquerel (MBq)	=	27 microcuries (μCi)
1 kilobecquerel (kBq)	=	27 nanocuries (nCi)
1 becquerel (Bq)	=	27 picocuries (pCi)