

**RADIATION INFORMATION
FOR HOSPITAL PERSONNEL**



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RADIATION INFORMATION
FOR HOSPITAL PERSONNEL

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RADIATION INFORMATION FOR HOSPITAL PERSONNEL

Table of Contents

- 1. INTRODUCTION 1
- 2. RADIATION 1
 - 2.1 Radiation Terms 2
- 3. BACKGROUND RADIATION 3
 - 3.1 Natural Radiation Sources 4
 - 3.1.1 External Sources 4
 - 3.1.2 Internal Sources 4
- 4. MAN-MADE RADIATION SOURCES 5
 - 4.1 Diagnostic Uses 5
 - 4.2 Therapeutic Uses 6
- 5. MEDICAL SOURCES OF RADIATION 6
 - 5.1 Diagnostic Sources 6
 - 5.1.1 Fixed X-Ray Machines 7
 - 5.1.2 Portable or Mobile X-Ray Machines 7
 - 5.1.3 Computed Tomography Scanners (CT) 9
 - 5.1.4 Radioactive Materials 10
 - 5.1.5 Laboratory Departments 11
 - 5.2 Therapeutic Sources 11
 - 5.2.1 Radiation Therapy Machines 11
 - 5.2.2 Radioactive Sources for Therapeutic Purposes 12
- 6. RADIATION PROTECTION METHODS 13
 - 6.1 Protection Against Radiation 15
 - 6.1.1 Time 15
 - 6.1.2 Distance 16
 - 6.1.3 Shielding 16
 - 6.2 Protection Against Radioactive Material Contamination 16
- 7. RESTRICTED AREAS 17
 - 7.1 Recognizing Radiation Areas 17
- 8. SPECIFIC INSTRUCTIONS FOR ALLIED MEDICAL WORKERS 19
 - 8.1 Housekeeping Personnel 19
 - 8.2 Security Personnel 19
 - 8.3 Maintenance Personnel 19
 - 8.4 Clerical Personnel 19
- 9. RADIATION SURVEYS AND PERSONNEL MONITORING 20
- 10. RADIOACTIVE MATERIAL PACKAGE RECEIPT 20
- 11. RADIATION EMERGENCIES 21
- 12. RADIATION SAFETY OFFICER 21
- 13. RADIATION AND PREGNANCY 22
- 14. RADIATION RISKS 23
- 15. ACKNOWLEDGMENTS 24

RADIATION INFORMATION FOR HOSPITAL PERSONNEL

List of Figures

Figure 1 - Electromagnetic Spectrum	2
Figure 2 - Background Radiation..	4
Figure 3 - External and Internal Radiation Sources	5
Figure 4 - Diagnostic X-Ray Machine..	8
Figure 5 - Fluoroscopy X-Ray Machine	8
Figure 6 - Mobile X-Ray Machine..	9
Figure 7 - CT scanner	10
Figure 8 - Gamma Camera in Nuclear Medicine	11
Figure 9 - Linear Accelerator in Radiation Oncology	12
Figure 10 - Brachytherapy Sources Used in Radiation Oncology..	14
Figure 11 - Time/Distance/Shielding	15
Figure 12 - Radiation Warning Sign(s)..	18
Figure 13 - Radioactive Source Storage	18
Figure 14 - Hospital Personnel Inspecting a Package	21
Figure 15 - Counseling Pregnant Worker	22

List of Tables

Table 1 - Radiation Units	3
Table 2 - Background Radiation Sources	7
Table 3 - Estimate of Risks	23

RADIATION INFORMATION FOR HOSPITAL PERSONNEL

1. INTRODUCTION

X-ray machines and radiation emitting sources are used in hospitals for the diagnosis and treatment of diseases. Some of the hospital employees who work in radiology, nuclear medicine, radiation oncology, and some laboratories are specifically trained in the operation of radiation machines and the handling of radioactive materials and sources. These personnel are called “occupational workers.” Other hospital workers may work around radiation sources, and may be indirectly exposed to radiation during performance of their normal duties. These employees are “allied medical workers” and may belong to nursing, housekeeping, maintenance, security, shipping/receiving, and clerical departments. In addition, patient transport, operating room, and recovery room personnel may come in contact with brachytherapy (radioactive implant) and nuclear medicine patients.

This booklet is designed to inform allied medical workers about the nature of radiation, its use in the hospital, and methods of radiation protection. The major areas covered in this booklet are:

- sources of radiation in the medical environment,
- radiation protection methods,
- instructions for workers,
- radiation risks and biological effects,
- and radiation exposure and pregnancy.

While the potential exposure to allied medical workers from radiation is very low, and the hazard (risk) is usually minimal, all radiation exposure should be kept to a minimum. Further information can be obtained from your Radiation Safety Officer (RSO). Let us begin by defining “radiation.”

2. RADIATION

What is radiation?

Radiation is a general term used to describe a bundle of energy in the form of electromagnetic waves. Radio waves, microwaves, ultraviolet (UV), x rays, gamma rays, and visible light are all forms of electromagnetic or EM waves. All EM radiation travels at the speed of light, 300,000 km/s (186,000 miles/s). Among all the EM radiations, only light is visible to the human eye. All other EM radiations cannot be seen and special instruments are

required to detect the presence of the invisible types of EM radiation. Figure 1 shows the electromagnetic spectrum, a comparison of energies and properties associated with different types of EM radiation.

The term radiation also is used to describe very fast moving particles, such as electrons and neutrons. These particles are found in the atom, which is the smallest part of any material. When the energy of the radiation is high enough, it can remove electrons from the atoms or molecules of a substance and is called ionizing radiation. Not all electromagnetic radiation causes ionization. Ionizing radiation can pass through materials, and is also called penetrating radiation. X rays and gamma rays are high-energy ionizing EM radiations and may simply be called "radiation."

In this document the term "radiation" refers to electromagnetic radiation that causes ionization. Penetrating radiations are useful in the diagnosis and treatment of diseases and are part of the backbone of modern medicine. However, because radiation can ionize and excite molecules, it can cause damage to living tissues. Therefore we must take precautions when using and working around it.

2.1 Radiation Terms

To detect the presence and measure the amount of radiation, sensitive and specialized instruments are used. Radiation is measured in radiation units: roentgen, rad, and rem. The "roentgen" is a measure of exposure—the amount of ionization in air produced by radiation at a location. The "rad" is the radiation absorbed dose and refers to the amount of energy absorbed by any material from the radiation. The "rem" determines the radiobiological equivalent and refers to the biological effect of the absorbed radiation on living things. From a practical, radiation safety concern, these radiation terms are frequently used interchangeably despite their different scientific definitions.

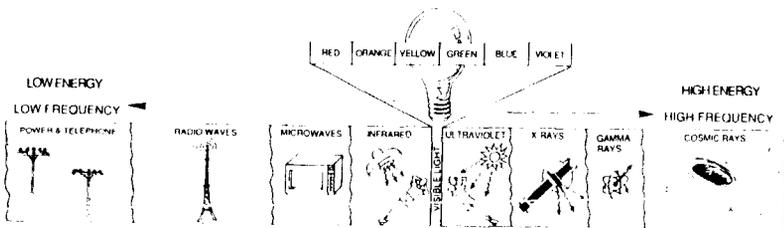


FIGURE 1. Electromagnetic Spectrum.

The roentgen, rad, and rem represent large quantities of radiation. Because only low levels of radiation are routinely present in the medical environment to which allied medical workers are exposed, smaller units are used. These are milliroentgen (mR), millirad (mrad) and millirem (mrem), and are one one-thousandth (1/1000) of the roentgen, rad and rem, respectively. Most personnel exposures and measurements are expressed in these smaller units. You may also encounter other, newer Système International (SI) radiation units for exposure, absorbed dose, and dose equivalent, such as the coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

For radioactive materials, the amount of radioactivity is measured in units of the curie (Ci). A smaller unit, the millicurie (mCi) is often used, which is one one-thousandth of a curie. This term describes the rate at which the radioactive material emits radiation. The SI unit of radioactivity is also being used and is the becquerel (Bq). Table 1 shows the old and the SI radiation units for various radiation quantities.

The amount of radioactivity present in a material decreases over time as a result of radioactive "decay." The period of time that it takes for a material to lose one half of its radioactivity is called its half-life. The half-life for different radioactive materials varies from fractions of a second to thousands of years. Radioactive materials are potential sources of contamination (radioactivity in places where it is not supposed to be). Contamination can cause radiation exposure.

3. BACKGROUND RADIATION

The radiations discussed in this booklet are x rays and gamma rays, which

TABLE 1. Radiation Units

Quantity	Unit	New Unit
Radiation Exposure	roentgen, R	coulomb/kg
Absorbed Dose	rad	gray, Gy
Dose Equivalent	rem	sievert, Sv
Radioactivity	curie, Ci	becquerel, Bq

1 R = 1000 mR

1 rad = 1000 mrad

1 rem = 1000 mrem

1 Gy = 100 rad

1 Sv = 100 rem

1 Ci = 37,000,000,000 Bq

are a form of ionizing radiation. Ionizing radiation can change chemical bonds in molecules of cells and therefore cause damage and produce biological effects. Some ionizing radiation is present naturally in the environment everywhere and is called "background" radiation. We are all exposed to these sources of radiation, which are usually in small quantities. Figure 2 shows the background radiation from the ground and the sky.

3.1 Natural Radiation Sources

3.1.1 External Sources

External sources of background radiation include: cosmic radiation, which comes from the sun and other sources in space, and terrestrial radiation, which arises from radioactive sources found in the earth and in some building materials. We receive more external radiation exposure from cosmic radiation when we climb mountains and fly in airplanes than when we are at ground level.

3.1.2 Internal Sources

Internal sources of background radiation include naturally occurring radioactive materials. We are born with some of them, some are deposited in our bodies from the food and water we eat and drink, and from the air we

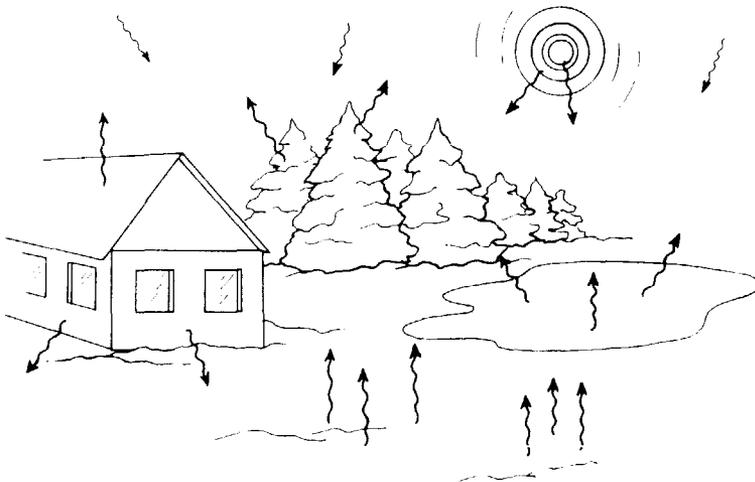


FIGURE 2. Background Radiation.

breathe. Radon, a naturally occurring radioactive gas, is present in many locations and exposes our lungs and bodies. The presence of this and other natural, internal sources in our bodies results in a small radiation dose. Some of the internal and external radiation sources are shown in Figure 3. The annual exposure from both external and internal sources of background radiation to a person in the United States varies from about 100 to 300 millirem, depending on location.

4. MAN-MADE RADIATION SOURCES

In addition to the natural sources of radiation, there are also man-made sources of radiation to which we may be exposed. In the United States, the largest source of exposure to a person is from medical procedures. Sources of radiation in medicine include x-ray machines and radioactive materials used in the diagnosis and treatment of diseases.

4.1 Diagnostic Uses

- X-ray machines, including mobile (“portable”) units, fluoroscopes (“C-arms”) and CT scanners.
- Radioactive materials (capsules, liquids, or gases) used in nuclear medicine for diagnostic procedures.
- Radioactive materials used in the laboratory to perform “in-vitro”

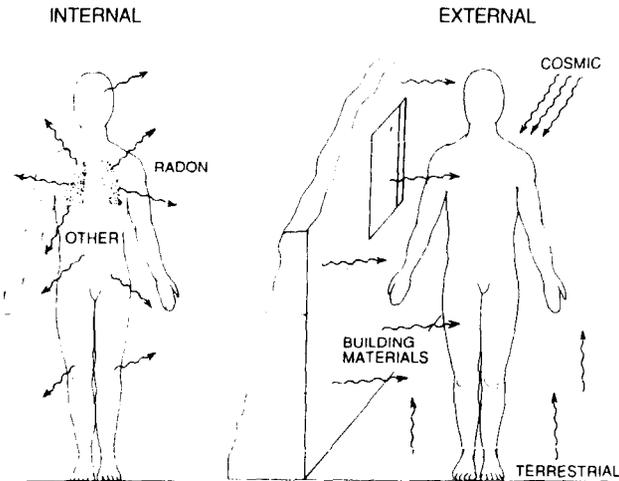


FIGURE 3. External and Internal Radiation Sources.

or test-tube studies on blood, urine, or cells for the diagnosis of diseases.

4.2 Therapeutic Uses

- Linear accelerators or teletherapy machines used in radiation therapy for the treatment of cancer and other diseases.
- Radioactive sources in small, sealed containers used for patient implants for treatment of cancer.
- Radioactive drugs used to treat patients.

Patients who receive large, therapeutic doses of radioactive drugs or brachytherapy implanted sources may pose risks to others and, as a consequence, they are typically confined to their hospital rooms. Workers who encounter any of the radiation sources described above should ask the following questions:

- What are the radiation sources in the area?
- Are they x-ray machines or radioactive materials?
- Where are the sources located?
- What safety precautions should I take to minimize my exposure?
- What should I do if I am accidentally exposed to these radiations?
- Whom do I ask for more information regarding radiation in my hospital?
- Is my exposure to radiation at an acceptable level?

The answers to these questions and others are discussed in the following sections.

Smaller amounts of radiation exposure also arise from consumer and electronic devices such as airport baggage inspection machines, televisions, computer terminals, and smoke detectors. Table 2 shows some background sources and the associated radiation levels.

5. MEDICAL SOURCES OF RADIATION

5.1 Diagnostic Sources

As listed earlier, diagnostic sources include x-ray machines and radioactive materials. X-ray machines are used in radiography and fluoroscopy, and they may be permanently installed (“fixed”) or mobile. Radiation protection methods are employed to reduce radiation exposure to the patient and others. In radiography, the exposure time is very short, usually less than one second, and x rays are emitted from the machine only when the control switch to the unit is turned ON by the operator. Personnel are typically not in the x-ray room during the time the x rays are being emitted.

In fluoroscopy the exposure time may be lengthy, and personnel usually

TABLE 2. Background Radiation Sources

Sources	Average Annual Dose (mrem/year)
Natural	
Cosmic	30
Terrestrial	30
Internal	40
Radon (Estimate)	200
Total Natural	300
Man-Made	
Medical	54
Consumer Products	5
Fallout	<1
Nuclear Power Plant	<1
Total Man-Made	<60

Adapted from NCRP Report No. 94. Exposure of the Population in the United States and Canada from Natural Background Radiation. National Council on Radiation Protection and Measurements, Bethesda, MD, 1987.

work in the room while the machine is emitting radiation; therefore, they wear protective aprons to minimize their risks. The control panel of the machine has lights and audible signals that indicate when the machine is emitting radiation. When the control switch is in the OFF position, x rays are no longer produced from the machine, and no radiation risks exist.

5.1.1 Fixed X-Ray Machines

These are primarily located in the X-Ray or Radiology Department, but they may be located in other areas of the hospital, such as operating rooms and emergency rooms. These x-ray machines are used in the diagnosis of disease. These are located in a specially shielded room and are typically operated by personnel trained in the proper use of the equipment. Figures 4 and 5 show typical diagnostic x-ray units for radiography and fluoroscopy, respectively.

5.1.2 Portable or Mobile X-Ray Machines

Mobile x-ray machines are similar in function to the fixed machines; however, they are mobile and are transported to the patients who cannot be moved. Mobile machines are typically used to examine patients in the Operating or Recovery Room during or after surgery, trauma victims in the

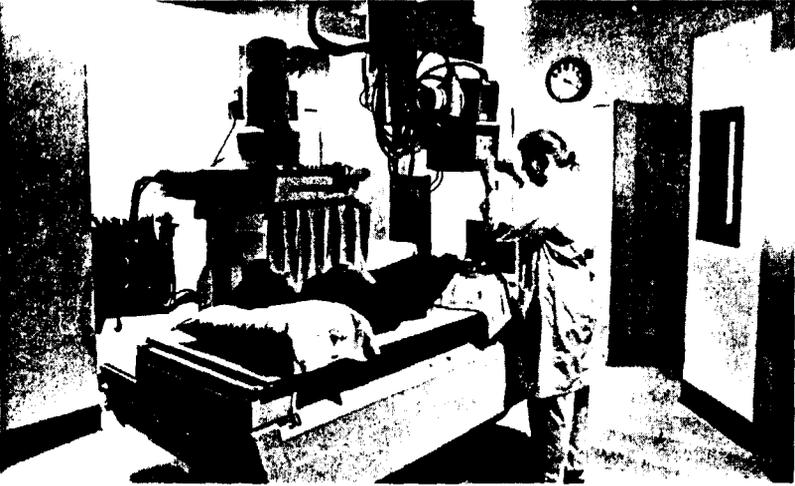


FIGURE 4. Diagnostic Radiography X-Ray Machine.

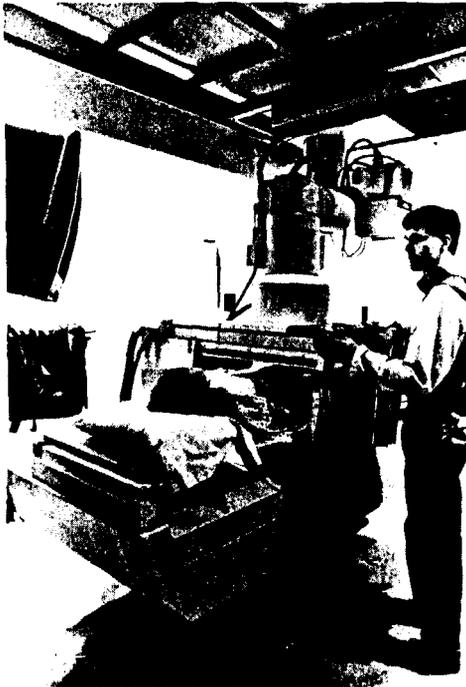


FIGURE 5. Diagnostic Fluoroscopy X-Ray Machines.

Emergency Room, patients located in intensive care units, neonatal units, and other bedridden patients. Figure 6 shows a mobile x-ray unit being used in a patient's room. Personnel and other patients may receive a small amount of exposure to x rays during the time that the x-ray machine is ON. Personnel who assist in holding patients should wear protective aprons, as should the operator.

5.1.3 Computed Tomography Scanners

Computed tomography scanners (CT or CAT scanners) may be located in the radiology and radiation oncology departments. These scanners use x rays and computers to produce images of the body in sections called slices. In CT, x rays are produced only when the unit is turned ON by an operator. A typical time of x-ray exposure in a CT procedure is 1-30 seconds. Figure 7 shows a CT scanner with a patient.



FIGURE 6. Mobile X-Ray Machine.



FIGURE 7. CT Scanner.

5.1.4 Radioactive Materials

Radioactive materials used in nuclear medicine are radioactive liquids, capsules containing radioactive materials, or gases. These radioactive materials may be administered intravenously to patients, or are swallowed or inhaled by them, in order to obtain an image of a particular organ or body system. Radioactive materials continually emit radiation and cannot be turned OFF. The patient is temporarily radioactive until the radioactive material decays to an acceptable level or is eliminated naturally by the body. Consequently, body fluids from these patients also can be radioactive, and appropriate precautions should be taken in handling them (e.g., normal nursing procedures such as wearing rubber gloves).

Many radioactive materials are potential sources of contamination (radioactivity in places where it is not supposed to be) and therefore are kept in the area called the "hot lab." The hot lab must be locked when unattended. Nuclear Medicine procedures involve the use of a machine called a "gamma camera" that detects and records radiations emitted by the radioactive materials administered to the patient. The gamma camera does not emit radiation; rather, it detects and records the distribution of the radiations emitted from the radioactive material in the patients. Figure 8 shows a gamma camera being used in a nuclear medicine department. The radioactive material administered depends upon the organ or system of interest.



FIGURE 8. Gamma Camera.

5.1.5 Laboratory Departments

Some laboratories use small amounts of radioactive material for “in vitro,” or test tube, diagnostic tracer studies. The amounts of radioactive material used are typically only a fraction of those used in nuclear medicine studies and generally do not pose any radiation risk as long as proper procedures are followed.

5.2 Therapeutic Sources

You will recall that the therapeutic sources include radiation therapy machines, radioactive materials in therapeutic amounts, and sealed radioactive sources that are implanted in patients.

5.2.1 Radiation Therapy Machines

Radiation therapy machines are located in heavily shielded rooms in the radiation therapy or radiation oncology departments. These machines deliver high doses of radiation for the treatment of cancer and other diseases. The radiation dose is prescribed by a radiation oncologist and administered by a radiation therapist. The radiation therapy machine may be a high-energy x-ray machine or may be a sealed radioactive source unit, which houses a high-activity sealed Cesium-137, Iridium-192, or Cobalt-60 radioactive source.

Alternately, the radiation source may be a high-energy machine, called a linear accelerator or linac, which produces x rays and electrons. A typical linear accelerator for the treatment of patients is shown in Figure 9. X rays and high-energy electrons are produced from the linear accelerator only when the beam is turned ON, similar to a diagnostic x-ray machine.

In units that utilize high-activity sealed radioactive sources, radiation is always emitted, even when the beam is OFF. When the beam is off, the source is well shielded so that the radiation levels in the room are very low, with no radiation hazards to personnel. Some radiation therapy departments may have x-ray machines for therapy that are called orthovoltage or superficial therapy x-ray units. These units are similar to the diagnostic x-ray machine, except that they operate for longer exposure times.

5.2.2 Radioactive Sources for Therapeutic Purposes

Radioactive sources used for therapeutic purposes and which are administered internally may be in sealed or unsealed containers. In both cases, the nursing care provided to the patient is limited to keep the exposure to nurses at acceptably low levels. Visitation must be authorized by the Radiation Safety Officer of the hospital. During the treatment, when the radiation level in the room is high, housekeeping personnel are not permitted to enter the patient's room for normal cleaning purposes. It is only after the patient has been discharged, and the Radiation Safety Officer has made sure that the

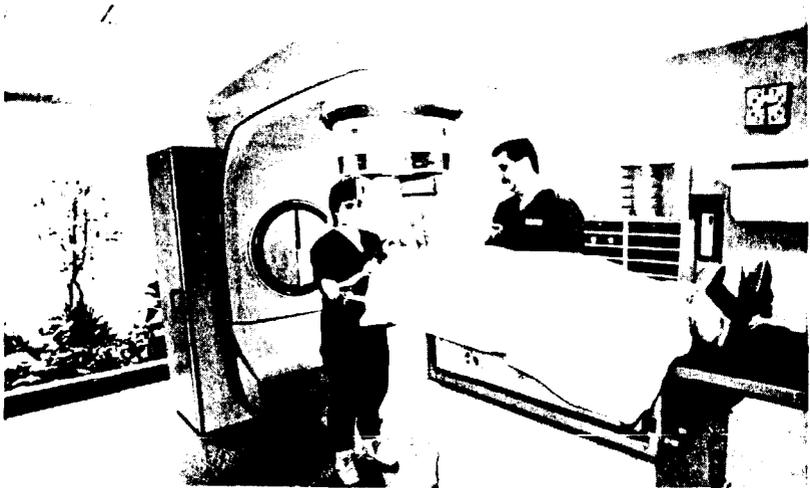


FIGURE 9. Linear Accelerator.

room is free from any source of radiation, that the room may be released to housekeeping personnel for cleaning purposes. Generally, patients treated by radioactive sources are hospitalized for a period of one to five days. Patients treated with sealed sources are not radioactive after the sources are removed.

Nuclear Medicine Sources: Radioactive materials in therapeutic amounts are administered to patients in the form of a liquid or capsule. These materials are highly radioactive, which means that the patients become sources of emitted radiation and radioactive contamination for a period of time. They remain radioactive until the administered radioactive material decays to an acceptable level, or is eliminated naturally by the body. The patient is typically confined to one room until the radioactive decay results in acceptably low radiation levels. The patient may cause significant contamination of items which they touch, and all such items must be tested before disposal.

Radiation Therapy Sources: Another method of therapeutic use of radiation is to implant radioactive sources in the form of sealed seeds or rods in patients. These patients are sources of radiation until the radioactive sources are removed or they have decayed to acceptably low radiation levels. These patients are sources of radiation but not contamination. The patient with temporary implants remains in isolation and is confined to a room until all the radioactive sources have been removed.

Very rarely, sealed sources come off of a patient and wind up in bed linen or on the floor. If you should ever see or suspect that such a source is dislodged *do not* touch or pick it up. Keep everyone away from it. Call the Radiation Safety Officer to investigate immediately. Some types of brachytherapy sources used in hospitals are shown in Figure 10. High dose-rate sources are contained in a specially shielded container. They are positioned near the patient's tumor for brief periods of time and then retracted back into the shielded container. The patient is usually treated as an outpatient and is not radioactive when she leaves the treatment room.

Summary: X-ray machines can be switched ON or OFF. They only emit radiation when they are turned ON. Radioactive material is always "ON" constantly emitting radiation. Radioactive materials can be shielded so that no radiation escapes from the container.

6. RADIATION PROTECTION METHODS

What safety precautions should one take to minimize radiation exposure?

Radiation protection is employed to protect against radiation produced

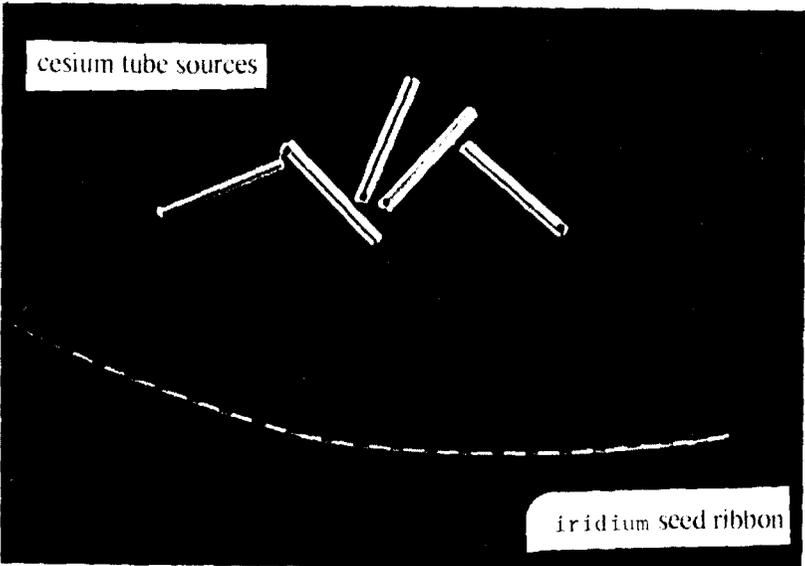
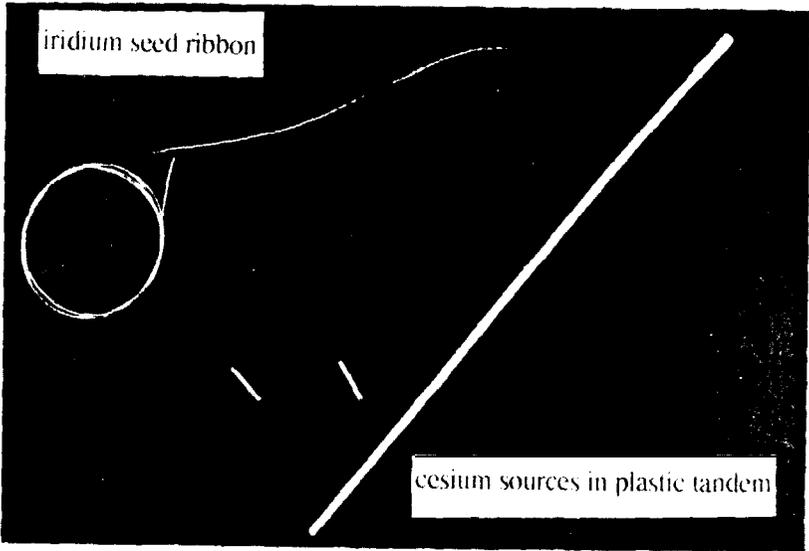


FIGURE 10. Brachytherapy Sources Used in Radiation Oncology.

from x-ray and gamma-ray machines, radiation emitted from radioactive materials, and to protect against contamination from radioactive material and sources.

6.1 Protection Against Radiation

How do we protect ourselves from radiation and reduce our exposure levels?

The most effective methods of radiation protection are to:

- 1) Minimize Time
- 2) Maximize Distance
- 3) Maximize Shielding

Figure 11 shows, schematically, these three methods for radiation protection.

6.1.1 Time

As the time spent in a radiation field increases, the radiation dose received also increases. Therefore, it is best to minimize the time spent in any radiation area. If working in and around radiation areas is a part of a person's assigned duties, then the person's work efforts should be organized and well planned in advance to limit the work time in the radiation area. This approach applies to nursing personnel taking care of confined therapy patients who have received radioactive materials or implants, housekeeping and

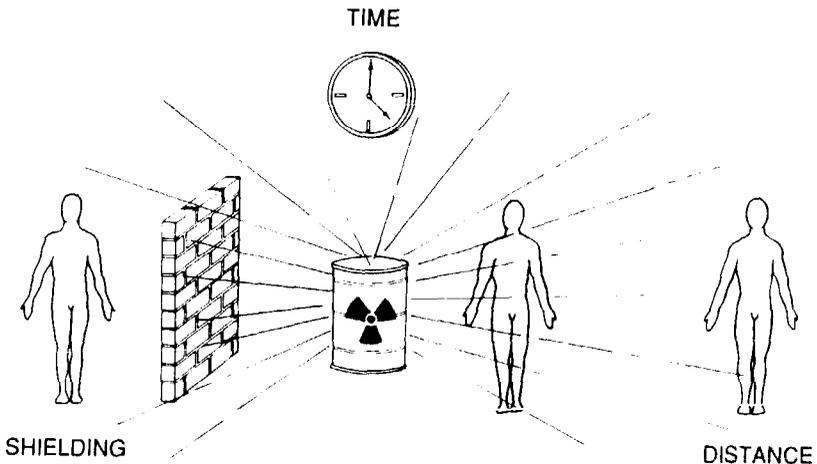


FIGURE 11. Time/Distance/Shielding.

maintenance personnel, and security personnel responsible for off-hours radioactive material package receipt and delivery. For radiation therapy treatments no one except the patient is allowed in the room so the exposure time to everyone else is zero.

6.1.2 Distance

Reduction of exposure due to an increase in distance is governed by the inverse-square law. As the distance from a radiation source increases, the radiation exposure decreases rapidly. Doubling the distance between a person and the radiation source reduces the radiation exposure to as little as one-fourth (1/4) of the original exposure. It is good practice to keep as much distance between yourself and the radiation source as is reasonably possible, even simply taking one step backward. Operating room or emergency room nurses are not always able to leave a patient unattended during a radiographic or fluoroscopic exam, but they can move away from the source as much as possible and wear lead aprons. An increase in distance from a source always reduces radiation exposure.

6.1.3 Shielding

Material that absorbs the radiation is a shield. The thicker the shielding, the more the radiation exposure decreases. Some materials are better than others. Lead and concrete are the most commonly used materials for shielding x rays and gamma rays. They are very effective in stopping or blocking the radiation beam. The walls of x-ray rooms are lead-lined to reduce the radiation exposure to those areas on the other side of the wall. Lead aprons, thyroid shields, and lead gloves are commonly used to shield body parts from diagnostic radiography and when portable x-ray machines are used. Lead bricks, lead vials, lead syringe shields and various other tools are used to reduce radiation exposure in nuclear medicine and radiation oncology departments.

6.2 Protection Against Radioactive Material Contamination

Contamination is the undesirable presence of radioactivity, such as a liquid spill on the floor, or on clothing. It is a potential hazard whenever unsealed radioactive materials are present. Avoid contaminating an area. Contamination can spread radioactivity to outside areas, including cars and homes, and can result in the accidental ingestion or inhalation of radioactive materials. Prevent contamination by using the same precautions followed when handling infectious agents, and biological and chemical sub-

stances. Wear rubber gloves and protective clothing. Because the radioactive contamination emits radiation, one must practice the protection methods described in the previous section. Remember that radioactivity or contamination cannot be seen. Radiation detecting instruments (survey meters) are used to survey when contamination is suspected.

Additional safe laboratory practices should be observed when personnel work with unsealed radioactive materials. Do not eat, drink, smoke, or apply cosmetics in any radiation areas. These precautions reduce the possibility of the accidental ingestion or inhalation of radioactive materials.

7. RESTRICTED AREAS

7.1 Recognizing Radiation Areas

The protection methods described above are effective when radiation areas are known, but how can allied medical workers know if they are in a radiation area? Areas with radiation sources or radioactive materials are defined to be "Restricted Areas," which are required by federal or state law to be posted with one or more of the following warning signs:

"Caution Radiation Area"

"Caution High Radiation Area"

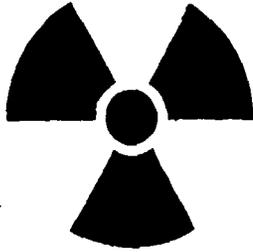
"Caution Radioactive Materials."

Figure 12 shows common radiation warning signs for radioactive materials and x-ray units. They have a yellow background with magenta or black lettering. Radiation warning signs should be posted within and around Restricted Areas. Figure 13 shows a radioactive source storage room where high activity radioactive sources are kept. The room and nuclear medicine hot lab may look alike. Both of them are used to store large amounts of radioactive materials. These rooms must be posted with "Caution Radioactive Materials" signs. If it is unclear as to whether or not an area is a Restricted Area, contact the Radiation Safety Officer of the hospital, or a staff member of the radiology, nuclear medicine, or radiation oncology department for clarification. Your Radiation Safety Officer will tell you whether you are allowed to enter these areas.

Every hospital employee should recognize restricted radiation areas in the work environment by looking for the radiation warning signs on:

- department and hallway doors,
- work areas within Restricted Areas,
- waste cans,
- package labels,
- and fume hoods, sinks, and refrigerators.

CAUTION



**RADIOACTIVE
MATERIALS**

CAUTION  RADIATION
THIS EQUIPMENT PRODUCES
RADIATION WHEN ENERGIZED

CAUTION  RADIATION
THIS EQUIPMENT PRODUCES
RADIATION WHEN ENERGIZED

FIGURE 12. Radiation Warning Signs.



FIGURE 13. Radioactive Source Storage Room.

8. SPECIFIC INSTRUCTIONS FOR ALLIED MEDICAL WORKERS

8.1 Housekeeping Personnel

All housekeeping employees should be aware of the locations of all Restricted Areas in order to practice good radiation protection measures. These measures are:

- 1) Recognize Restricted Areas in your work environment.
- 2) Get user permission and instructions from the Radiation Safety Officer before cleaning any spill in a Restricted Area.
- 3) Do not clean counter tops, hoods, refrigerators, or sinks in Restricted Areas unless specially requested and instructed by the area supervisor or Radiation Safety Officer.
- 4) Do not remove bedclothes, dishes, trash, or other items from rooms posted with radiation signs, unless specifically instructed by a member of the Radiation Safety Staff.

8.2 Security Personnel

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

8.3 Maintenance Personnel

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

- 1) Recognize Restricted Areas in your work environment.
- 2) Obtain permission before working in an area that is in or adjacent to a Restricted Area.
- 3) Be aware of hoods, sinks, refrigerators, and storage areas used for radioactive materials or sources.

8.4 Clerical Personnel

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

- 1) Recognizing Restricted Areas in your work environment.
- 2) Refraining from eating, drinking, applying cosmetics, and smoking in areas where radioactive materials are used.

- 3) Prohibiting food or soft drink storage in refrigerators used for the storage of radioactive materials.

9. RADIATION SURVEYS AND PERSONNEL MONITORING

How do I know that radiation levels are within acceptable limits?

Radiation surveys are measurements of radiation levels with specialized instruments. A radiation survey of x-ray equipment and adequacy of room shielding is conducted by the Medical Physics or Radiation Safety staff to document the radiation levels present during operation. At the time of installation, an in-depth safety evaluation of the radiation machine is performed before it is used for patient examinations or treatments. In addition to these surveys, periodic quality assurance checks are required.

Areas where radioactive materials are used, prepared, or stored are monitored for radiation levels on a periodic basis, which may be daily, weekly, monthly, or quarterly, depending on the type of use and the legal requirements. These surveys are conducted with the use of hand-held radiation survey instruments. The measured radiation levels are then compared to allowable limits. Surveys are conducted in an effort to keep radiation exposures As Low As Reasonably Achievable (ALARA) for everyone.

In addition to the physical surveys described above, some workers must be monitored for radiation exposure with personnel dosimetry devices, such as film badges, ring badges, or pocket dosimeters. These devices are intended to record only the radiation exposure that an individual receives as a result of employment at a particular facility. The personnel monitoring device should never be exchanged between individuals. After the device is worn for a specified period of time, it is returned to the place of evaluation. The radiation dose is evaluated and recorded as a permanent record of exposure for that individual, which becomes a legal document. Personnel exposure records for each individual are maintained for a long period of time, and the individual's occupational dose is for that individual's lifetime.

10. RADIOACTIVE MATERIAL PACKAGE RECEIPT

Radiation surveys should be performed on all packages containing radioactive materials delivered to or shipped from the hospital. Packages containing radioactive material are typically delivered to a designated location, such as the nuclear medicine department, during normal working hours when the staff is available to conduct the required monitoring. Sometimes deliveries may be made during off-hours. Each facility is required to have specific procedures for radioactive material package receipt, which include pro-

cedures for package inspection, receipt records, delivery to appropriate department, notification of appropriate personnel, and off-hour receipt. Check with your Radiation Safety Officer for specific procedures of your facility. Figure 14 shows inspection of a package for radioactivity.

11. RADIATION EMERGENCIES

Each facility has procedures for the control of Radiation Areas during an emergency. These procedures should be brought to the attention of allied medical workers at the time of orientation and during their radiation safety continuing education sessions. Contact the Radiation Safety Officer for explicit instructions for the safety of Radiation Areas in the event of:

- fire,
- flood,
- explosion,
- unsecured radiation area,
- theft or vandalism,
- or the presence of suspicious persons.

In case of emergencies in restricted areas, call the Radiation Safety Officer whose telephone number is posted at each Restricted Area.

12. RADIATION SAFETY OFFICER

The Radiation Safety Officer (RSO) is designated by the hospital admin-



FIGURE 14. Inspection of Incoming Package.

istration and authorized by the State and/or Nuclear Regulatory Commission (NRC) to oversee the radiation safety program in the hospital for radioactive materials. An RSO must meet specific training and experience criteria. The name of the RSO and a 24-hour telephone contact must be posted wherever radioactive materials are used or stored.

In addition to the emergencies described above, an RSO can be contacted for the following:

- personnel exposure data, if you are monitored for radiation or feel that you should be;
- regulations, license, and inspection reports;
- if you are pregnant and you work in Restricted Areas;
- if you have questions or suspect problems about radiation;
- or if you want to know about the NRC and other federal or state regulatory agencies regarding radiation protection.

13. RADIATION AND PREGNANCY

It has been known since the early 1900s that cells that reproduce more frequently are more sensitive to radiation damage. Because embryos, fetuses, and children are growing, and therefore their cells are reproducing more often, they are typically more sensitive to radiation than adults. When the abdomen of a pregnant female is exposed to radiation, a fraction of that exposure is also received by the embryo or fetus. The most radiosensitive



FIGURE 15. Counseling Pregnant Worker.

period for the embryo is from 8 to 15 weeks gestation age.

Allied medical workers who may be exposed to radiation should contact the RSO if they become pregnant or are planning to become pregnant.

Instructions given to radiation workers should include information regarding prenatal exposure risks to the developing embryo and fetus. This information is used by the employee in the event of pregnancy to assess the risks associated with her particular employment duties and any possible alternative work environments if deemed necessary. The radiation dose equivalent to the embryo/fetus is considered separately from the maternal dose, and the radiation limits during the nine-month gestation period are 500 mrem for the embryo/fetus.

It is important to note that the mother assumes all risk until she specifically declares her pregnancy, in a written and signed statement, to her supervisor or the RSO. At that time, the hospital is responsible for assuring that the duties of a female worker will not result in a dose equivalent that is more than 500 mrem to the fetus. Figure 15 shows a pregnant worker with a radiation counselor. Personnel should be encouraged to contact the RSO to discuss any matter regarding radiation.

14. RADIATION RISKS

In today's society, many of our daily activities involve risks. Generally, a

TABLE 3. Estimates of Risk

Health Risk	Estimate of Days of Life Lost
Smoking 20 cigarettes/day	2370 (6.5 years)
Overweight (by 20%)	85
All accidents combined	435 (1.2 years)
Auto accidents	200
Alcohol consumption (US average)	130
Home accidents	95
Drowning	41
Natural background radiation, 100-300 mrem per year	8
Medical diagnostic x-rays (US average)	6
All catastrophes (earthquakes, etc.)	3.5
Occupational radiation dose, 1 rem (1000 mrem)	1
1 rem/yr for 30 years	30

Industry average for the higher-dose occupations is 0.65 rem/yr or 650 mrem/yr. Adopted from: B. Cohen and I. Lee. A catalogue of risks. Health Physics 36:707-722, 1979.

risk can be defined as “the possibility or chance of illness, injury, or even death that may result from some activity.” For a patient, the risk associated with the radiation exposure received from a particular exam is typically outweighed by the benefit of the diagnosis or treatment received.

A useful measure for comparing the risk associated with radiation to other kinds of health risks is the average number of days of life expectancy lost per unit of exposure for each type of risk. These estimates indicate that many of our day-to-day activities represent a higher health risk than our risk from the radiation levels encountered in the medical work environment. Some risk factors associated with various activities are presented in Table 3.

15. ACKNOWLEDGMENTS

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