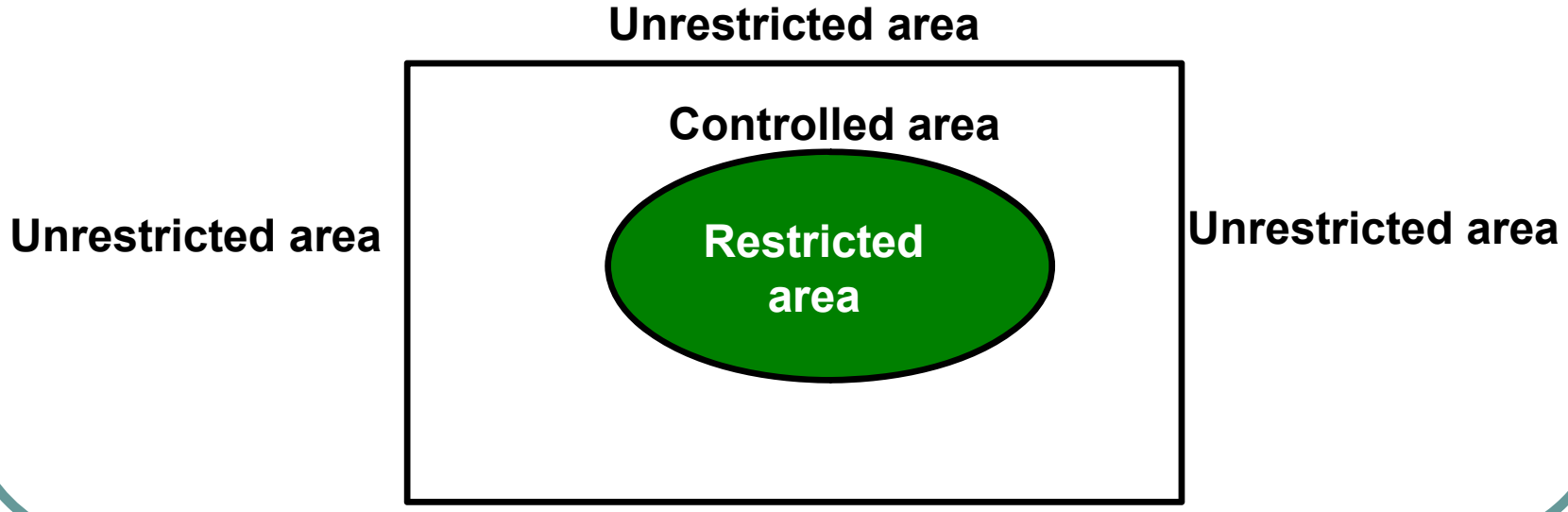
Clinical Radiation Safety/ALARA Program in Therapy

ALARA Defined

ALARA means " making every reasonable effort to maintain exposures to radiation far below the dose limits, consistent with the purpose of the licensed activity."



10 CFR Part 20

As low as reasonably achievable (ALARA) is no longer an addendum to the NRC license application. It is now a part of NRC regulations under 10 CFR Part 20.

Part 20

Each Licensee shall develop, document, and implement a radiation protection program commensurate with the scope and exact licensed activities and sufficient to ensure compliance with the provisions of Part 20.

Part 20

The licensee shall use, *to the extent practical*, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as reasonably achievable (ALARA).

Radiation and Radioactivity

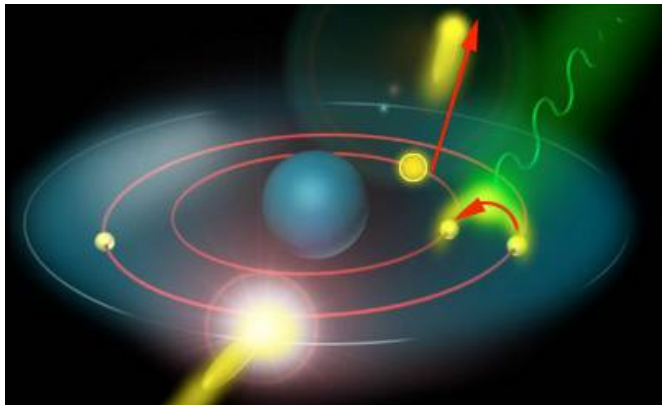
- Radiation: Energy in transit, either particulate or electromagnetic in nature
- Radioactivity: The characteristic of various materials to emit ionizing radiation
- Ionization: The removal of electrons from an atom. The essential characteristic of high energy radiations when interacting with matter.

Ionizing Electromagnetic Radiation

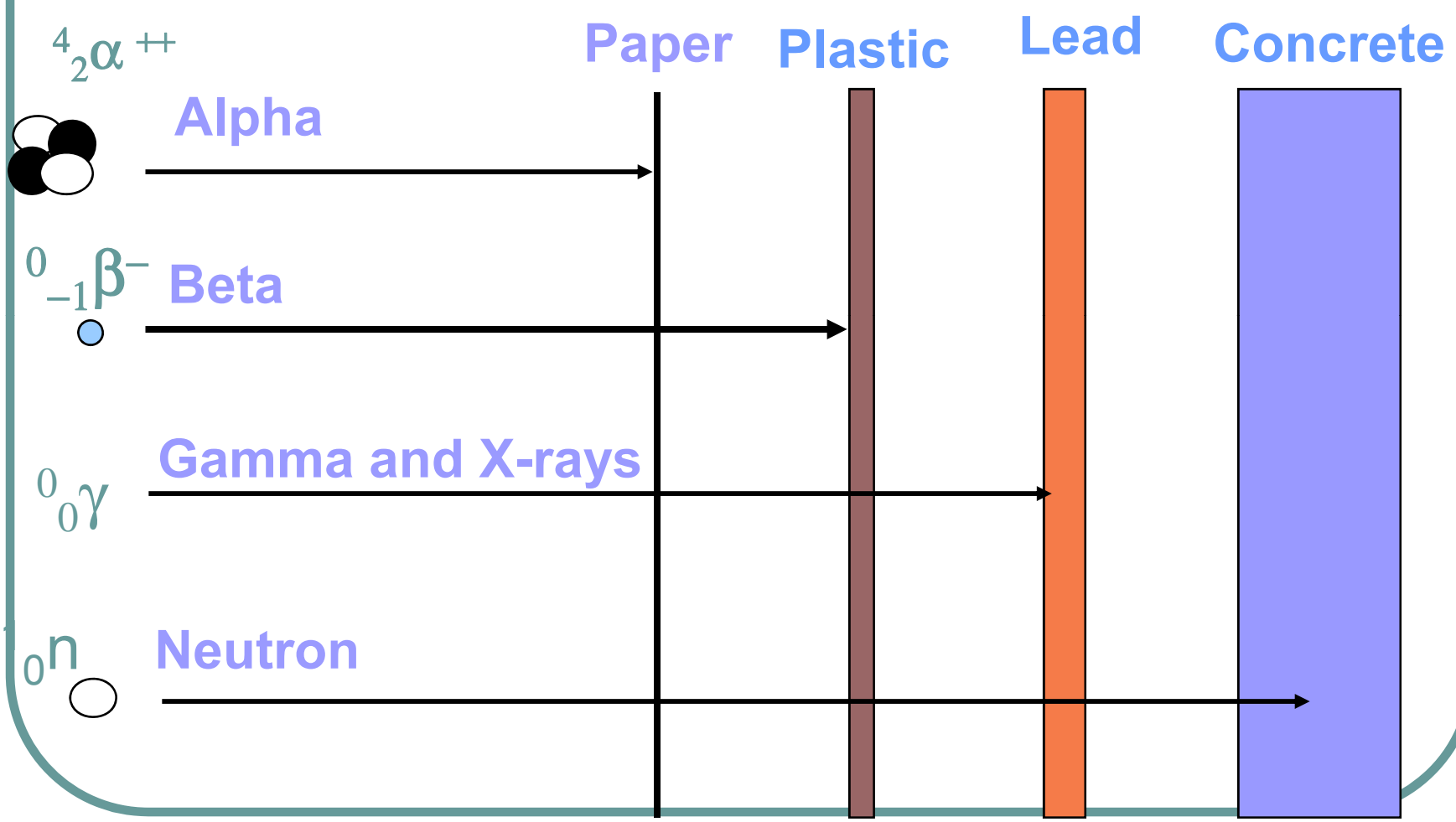
These radiations have enough energy to remove electrons from atoms

Examples:

- X-rays
- Gamma rays



Types of Radiation

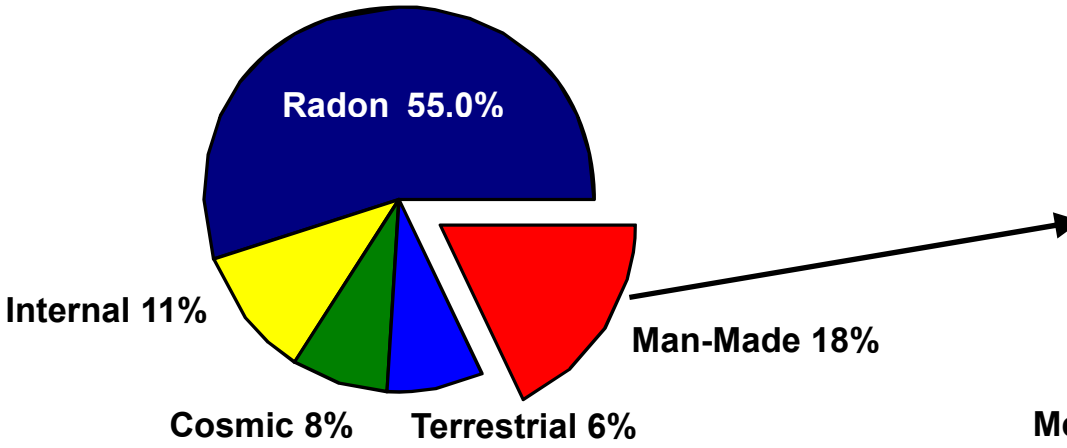


Types of Radiation

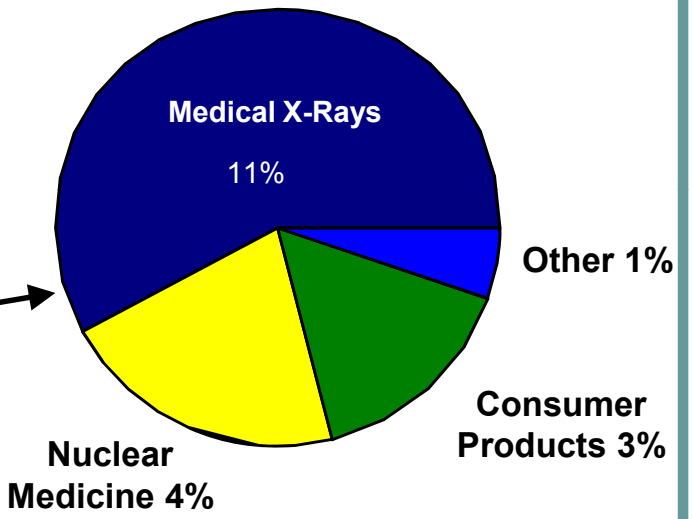
	Mass (amu)	Charge	Travel Distance in Air
Alpha	4.0000	+2	few centimeters
Beta Plus	0.0005	+1	few meters
Beta Minus	0.0005	-1	few meters
Gamma	0.0000	0	many meters
X-Rays	0.0000	0	many meters
Neutron	1.0000	0	many meters

Annual Dose from Background Radiation

Total exposure



Man-made sources



Total US average dose equivalent = 360 mrem/year

Radiation Protection Basics

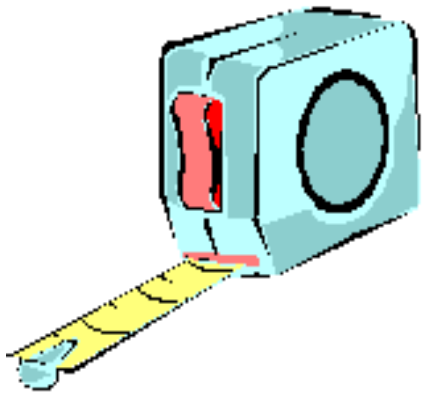
- **Time:** minimize the contact time with radioactive material to reduce exposure
- **Distance:** increase your distance. Doubling the distance drops the exposure rate by one fourth
- **Shielding:**
  - Paraffin, Glass, Lead, water, or concrete for gamma & X-ray
  - Thick plastic (Lucite) for betas
  - Water, plastic or boron for neutrons

Time

The total exposure received is the product of the **exposure rate** (determined in part by the kind and amount of radioactive material present) and the exposure **time.** Work quickly (but safely) to minimize the exposure time.

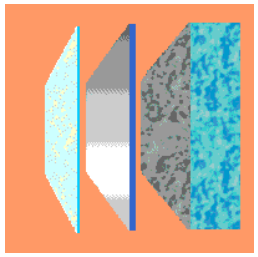
Distance

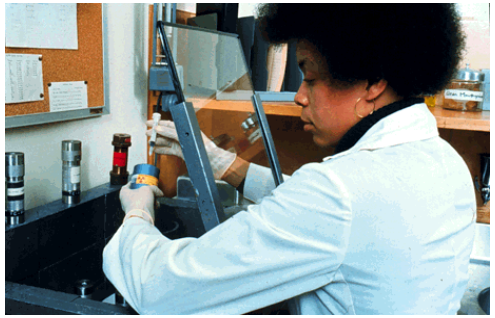
Radiation exposure obeys an **inverse-square law.** That is, if you double your distance from a radiation source, you reduce the exposure rate by a factor of four. Work at a maximum comfortable distance and use long tongs or forceps to reduce finger exposure.



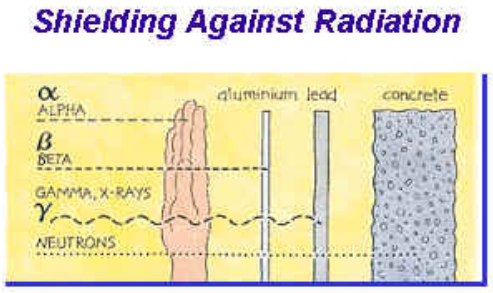
Shielding

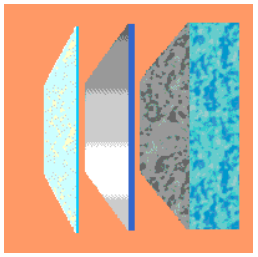
Low-energy beta emitters (<250 keV), such as C-14 and H-3, are stopped in a few centimeters of air and require no shielding. High-energy betas (>250 keV) like P-32 require several millimeters of plastic to stop. Avoid using bare lead to shield P-32, since secondary x-rays (Brehmstrahlung) are produced.





Shielding





Gamma rays (such as from I-125, Na-22 or Cr-51) require lead or tungsten as a shielding material. Neutrons are not effectively shielded by lead; they require high-proton materials such as water, paraffin or concrete. High energy (>250 keV) betas (e.g. from P-32) should be shielded by Plexiglas to minimize Bremstrahlung X-rays.

Radiation Monitoring

There are two types of monitoring.

- Personal monitoring
- Area or environmental monitoring

Personnel Radiation Monitoring

10 CFR 20, subpart F

Most Common Personnel Radiation Monitoring

- Film badges
- OSL badges
- TLD

Standards for Protection Against Radiation

- Occupational limits for radiation workers
  - 5,000 mrem / year TEDE
  - 50,000 mrem / year CDE (any single organ)
  - 15,000 mrem / year lens of the eye
- Members of public
  - 100 mrem / year
  - No more than 2 mrem in any one hour in unrestricted areas from external sources
- Fetus of declared pregnant radiation workers (occupational)
  - 500 mrem / term (evenly distributed)

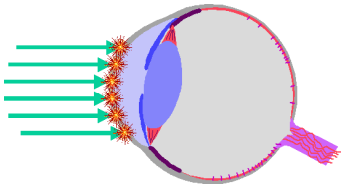
Anticipated Exposures

- Non-radiation workers must receive less than 100 mrems / year
- Average annual background exposure for U.S. population = 360 mrem / year
- State and federal exposure limits for radiation workers = 5000 mrem / year
- Anticipated exposures: Less than the minimum detectable dose for film badges (likely less than 10 mrem / month) - essentially zero

Annual Occupational Dose Limits - 10 CFR 20

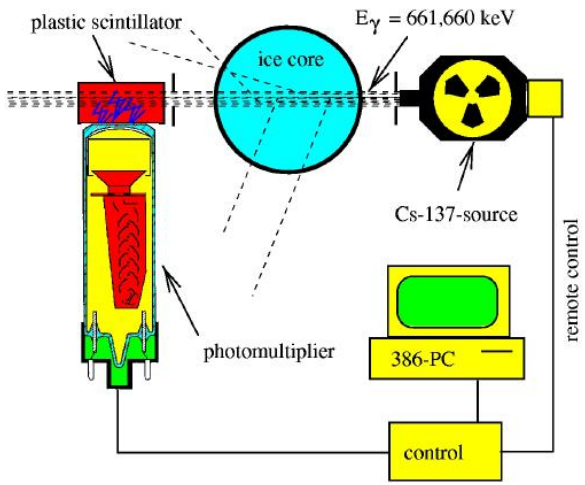
- Total effective dose equivalent to **whole body**: 5 rem (5,000 millirem)

- Lens of **eye**: 15 rem (15,000 mrem)



- Sum of deep-dose and committed dose equivalents to all other **tissues and extremities**: 50 rem (50,000 mrem)

Radiation Survey Instruments



Radiation Detector Types

- Gas Filled Detectors
  - Geiger Mueller (GM)
  - Gas Flow Proportional Counters
  - Ionization
- Scintillation Detectors
  - Sodium Iodide (NaI)
  - Zinc Sulfide (ZnS)
  - Anthracene
  - Plastic Scintillators
- Solid State Detectors
  - Germanium Lithium High Purity
  - Silicone Lithium
  - Silicone Diode
  - Cadmium Telluride

Ionization Chambers

Ionization chambers are used when accuracy is important.

Geiger Mueller Survey Meters

Geiger Mueller survey meters amplify the signal. They are commonly used to locate radioactive sources or find areas of contamination.

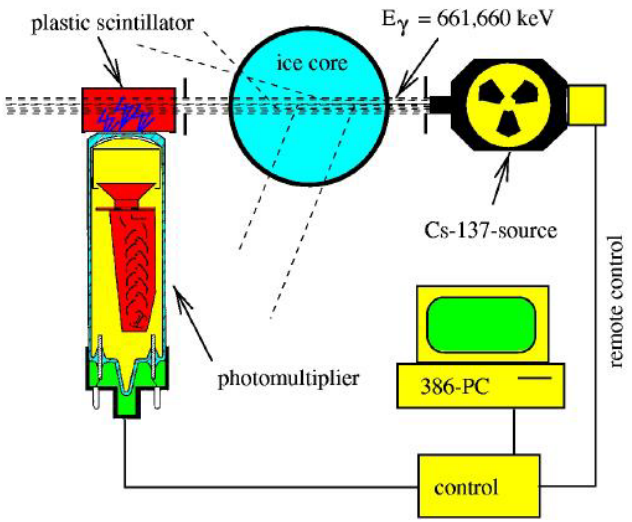
Beta Detectors

Beta detectors are just Geiger counters with attached specialized probes.

Gas Filled Detectors

- Ionization detectors
  - High Cost
  - Survey meters
  - Reference class calibration chambers
- Proportional counters
  - High cost
  - Gross laboratory measurements
  - Contamination monitors
- Geiger Mueller (GM) detectors
  - Low cost
  - Survey meters
  - Contamination monitors

Scintillation Detectors



Scintillation detectors are used when the radiation source is very weak.

Scintillation Detectors

- **One of the Oldest Detection Methods, Still Widely Used Today**
- **Transducer Converts Radiation Energy to Visible Light**
- **Visible Light Signals Amplified With Photomultiplier Tube**
- **Output PM Tube Signal Processed**
- **High Efficiency For Photon Detection Compared To Gas-Filled Detectors**

CPM & DPM

- **A radiation detector will not detect every disintegration from a source (i.e., they are not 100% efficient)**
- **Counts per minute (cpm) is the number of disintegrations that a detector "sees"**
- **The efficiency of a detector is determined by the following:**

Efficiency = net cpm / dpm

= gross cpm – background cpm / dpm

Brachytherapy Sources

All sources used in Brachytherapy must have a safety certificate from the manufacturer stating that the source conforms to standards set by the International Organization for Standards.

Brachytherapy Sources-Sealed Storage

A brachytherapy source inventory must include:

- The name of individuals permitted to handle the sources
- The number and activity of sources removed from storage, the patient's name, the date and time and initials of the person removing the sources
- The number and activity of sources returned to storage, the patient's name, the date and time and the initials of the person removing the sources,

Radiation Safety Instruction for Personnel caring for the patient and to the patient.

- Radiation levels measured during the radiation survey of the room and contiguous areas after the implant.
- The size and appearance of sources used, in case sources dislodge
- Safe handling and shielding instructions in case of dislodgement

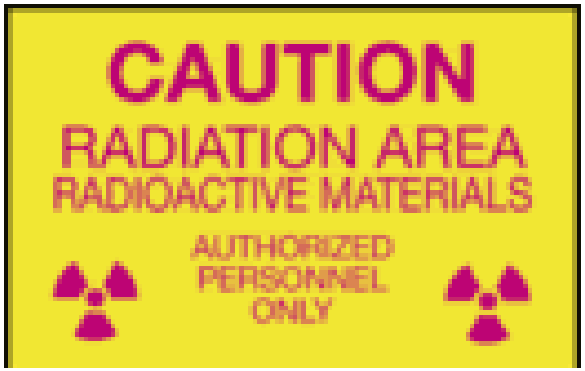
Radiation Safety Instruction for Personnel caring for the patient and to the patient.

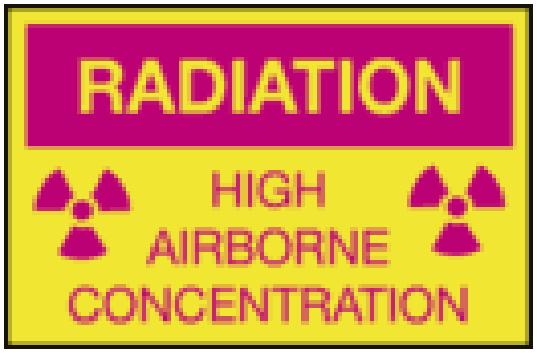
- Procedures and time limitations for visitors and nursing staff
- Restrictions on visitors (no children, pregnant women, etc.)
- Procedures for notification of licensee or Radiation Safety Officer in case of an emergency

Room Survey

After treatment is complete and the sources are removed from the patient, a radiation survey of the patient and room must be performed to make sure no sources were left behind.

POSTING SIGNAGE - Subpart J of 10 CFR 20





There are only a handful of radiation signs that an individual will encounter in a hospital or clinic.

Transport Labels on Packages of Radioactive Material

Radioactive white I; almost no radiation (0.5 mR/hr or 0.005 mSv/hr) maximum on the surface

Radioactive yellow II; low radiation levels (50 mR/hr or 0.05 mSv/hr) maximum at 1 meter

Transport Labels on Packages of Radioactive Material

Radioactive yellow III; higher radiation levels (200 mR/hr or 2 mSv/hr) maximum on surface. 10 mR/hr or .1 mSv/hr maximum at 1 meter.

The transport index is the maximum radiation level (in mR/hr) at 1 meter from the surface of an undamaged package.

10 CFR 35 Section 35.67

All sources must be tested for sealed leakage before first use, unless the licensee has a certificate from the supplier indicating that the source was tested within six months prior to transfer to the licensee.

Leak Test

If a leak test detects radiation that exceeds 185 Bq., the source must be immediately withdrawn from clinical use and stored, disposed of, or sent for repair (the licensee must file a report).

Section 35.604

The licensee must survey a patient treated with a remote after loader unit to make sure the source has retracted inside the unit and the patient is free of radiation.

35.610 requirements

- Treatment units must remain secured when not in use.
- Treatment units are used only by authorized and knowledgeable users specified in the license.
  - Users receive yearly training
  - Drills for response are documented
- Require detailed written guidelines exist for responses to emergency situations
- Operating procedures must be available at the console.
- Names and phone numbers of individuals to reach in case of an emergency must be posted.

Section 35.615

- Each treatment room will have an entry door equipped with an electric interlock system that prohibits initiation of treatment unless the door is closed.
- Following an interlock interruption, the source will not be exposed until all treatment room doors are closed and control is reset at the console.

Section 35.615

- Radiation room monitors will be located so that any individual entering the treatment room will know if radiation levels have returned to normal.
- Each room will be equipped with viewing and intercom systems to permit continuous observation of the patient from the treatment console during irradiation unless a low dose afterloader is being used..

Section 35.615

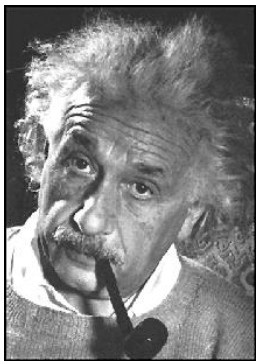
- Only source applicators that can be removed expeditiously in the event of a decoupled or jammed source will be used inside the patient's body.
- For HDR an authorized medical physicist and an authorized user (physician), who has been trained in the operation and emergency response unit, will be physically present during all treatments.

Section 35.615

- A licensee shall have applicable emergency response equipment available near each treatment room to respond to a source that fails to retract.
- The Radiation Safety Officer and an authorized user will be notified as soon as possible if the patient has a medical emergency or dies.

Section 35.643

This section lists the situations where a licensed medical physicist or his designee shall perform operational And safety checks on a remote afterloader.



Section 35.645

This section lists the situations where a licensed medical physicist or his designee shall perform operational and safety checks on gamma stereotactic radiosurgery units.

Section 35.657

This section addresses the therapy-related computer systems used to prepare the treatment parameters used at the console.

Radiation Safety Officer & Radiation Safety Committee

If the criteria for 35.24 is meet, the radiation safety program must be implemented by the **RADIATION SAFETY COMMITTEE** under the direction of the **RADIATION SAFETY OFFICER.**

Training Requirements for Radiation Safety Officer (5 pathways)

Degree or Certification	Experience	Certification Examination	Classroom Laboratory Training	Preceptor Statement	Special training
B or GD in PS; or, E or BS with 20 cc in PS	and 5 or more yrs in HP including 3 yrs in	yes		and has written attestation by preceptor	*and* training in RS regulatory issues, & emergency procedures
M or PhD in P, MP, or PS, E, AM	AHP *and* 2 yrs. full-time training in MP under supervision by CMP, or, in CNM, by physician AU	yes		and has written attestation by preceptor	*and* training in RS regulatory issues, & emergency procedures
	1 yr full-time RS under supervision by RSO		and 200 hrs in topical areas	and has written attestation by preceptor	*and* training in RS regulatory issues, & emergency procedures
CMP				and has written attestation by preceptor	*and* training in RS regulatory issues, & emergency procedures
AU, AMP, or ANP on license	and applicable experience			and has written attestation by preceptor	*and* training in RS regulatory issues, & emergency procedures

Radiation Safety Committee

- Review credentials of proposed authorized users (physicians)
- Review radiation protection program
- Meet quarterly (or as specified by the license)
- Review exposures, incidents, recordable and medical events
- Provide the radiation safety officer with authority to enforce the ALARA principles

Radiation Safety Officer

Duties include:

- Make all staff aware of ALARA program
- Identify radiation safety problems
- Initiate, recommend, or provide corrective actions
- Stop unsafe operations, verify implementation of all corrective actions
- Educate nursing staff in correct procedures to minimize exposures when caring for radiation patients