Radiation Worker Training

Quote for Today

Some say:

“A Little Knowledge is a Dangerous Thing”

After reviewing this material you will have:

“A Little Knowledge to Avoid Dangerous Things”

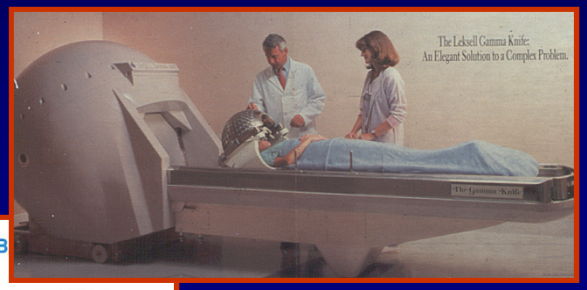
Topics

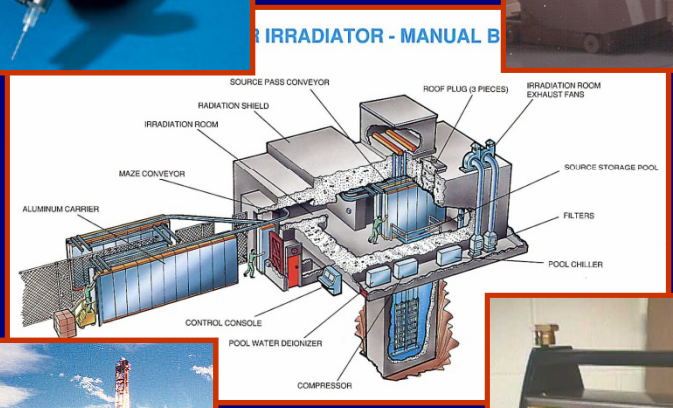
Overview

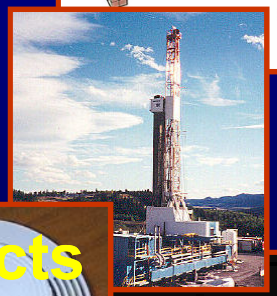
- Part 1 - Fundamental Concepts
- Part 2 - Biological Effects
- Part 3 - Standards & Guides
- Part 4 - Controlling Exposure
- Part 5 - Dose Evaluation
- Part 6 - Industrial Safety

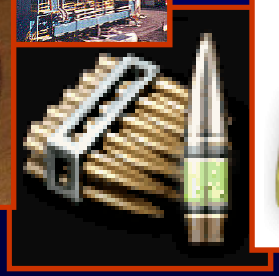
Sources of Radiation

- Medical
  - Diagnosis
  - Treatment
- Industrial
  - Irradiators
  - Radiography
  - Well Logging
  - Gauges
- Commercial Products
- Nuclear Power
- Weapons



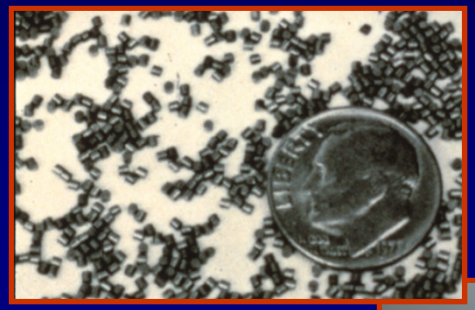


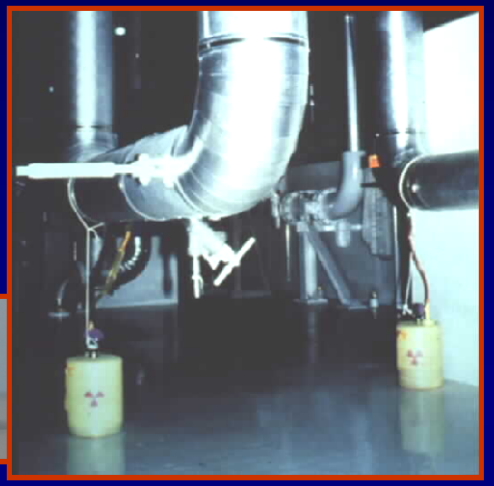


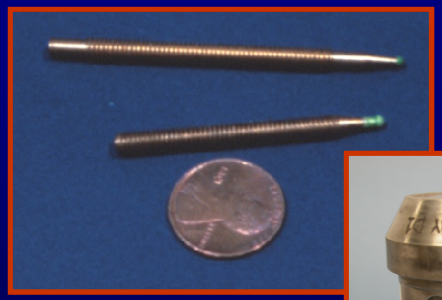


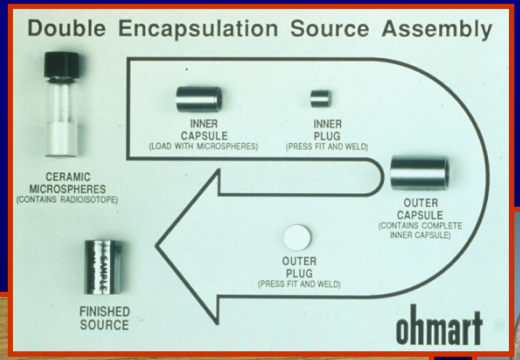
RWT

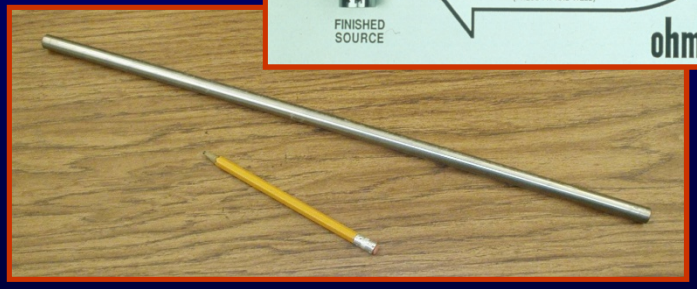
Radiation Sources











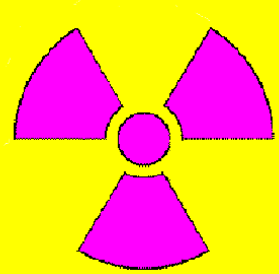
Radiation Safety

- You Should Use Common Sense
  - Step 1 - be aware of your surroundings
  - Step 2 - recognize a potential hazard
  - Step 3 - avoid the hazard
  - Step 4 - when in doubt

STOP & ASK

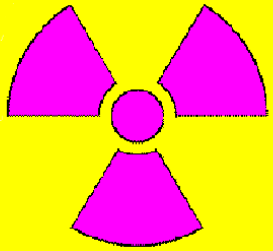
Radiation Warning Signs

CAUTION



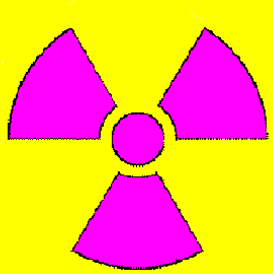
RADIATION AREA

GRAVE DANGER



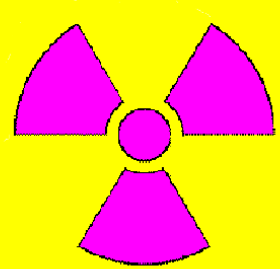
VERY HIGH RADIATION AREA

CAUTION



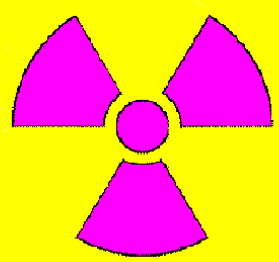
AIRBORNE RADIOACTIVITY AREA

DANGER



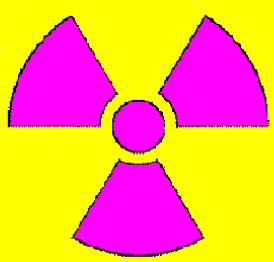
HIGH RADIATION AREA

CAUTION



RADIOACTIVE MATERIAL

RADIOACTIVE MATERIAL



EATING, DRINKING AND SMOKING PROHIBITED

Real Signs - Real Places

Radiation - Pros and Cons

Radiation may be both beneficial and harmful:

- **Some Beneficial Uses:**
  - **Medical**
  - **Industrial Applications**
  - **Commercial Products**
- **Some Harmful Effects:**
  - **Death**
  - **Injury**
  - **Cancer**

ALARA

A **L** **A** **R** **A**

s **o** **s** **e** **c**

w **a** **h**

s **i**

o **e**

n **v**

a **a**

b **b**

l **l**

y **e**

MD 10.131, "Protection of NRC Employees Against Ionizing Radiation"

- Keep doses to NRC employees ALARA
- Provide dosimeters when required
- When a site has an approved radiation safety program, rely on the program while at the site
- NRC employees shall comply with the requirements established by the site radiation safety program.

Responsibilities of Employees (MD 10.131)

- Comply with standards and procedures
- Make every reasonable effort to keep dose ALARA
- Use safety and Personal Protective Equipment provided
- Use correct, safe practices and follow the licensee's radiation safety procedures while on site
- Report radiation hazards to a supervisor ASAP
- Inform RSO of your occupational exposure history
- Exchange dosimeters and report if lost or damaged
- Females may voluntarily declare pregnancy (RG 8.13)

Part 1 - Fundamental Concepts

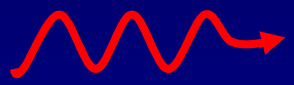
- Ionizing Radiation
- Types and Characteristics
- Quantities and Units
- Terminology

Radioactive Material (RAM)

- Material which spontaneously emits radiation
- May be in any form:
  - Solid
  - Liquid
  - Gas
- It's everywhere – some is man-made and some is just there naturally

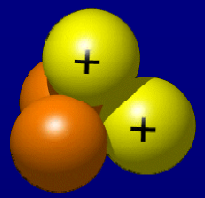
Types of Radioactive Material

- Gamma emitters (γ)



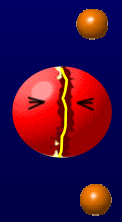
- Beta emitters (β)

- Alpha emitters (α)

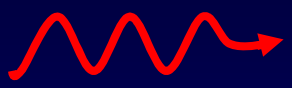


- Neutron emitters (η)

- Fissionable Material (criticality)



Gamma Emitters



Sample Applications	Sources
Irradiators	Cobalt-60
Medical	Iridium-192
Industrial Radiography	Iridium-192
Fixed Gauges	Cesium-137

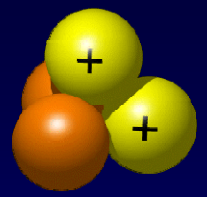
- penetrates the body easily
  - lots can kill you, less can cause cancer
- normally don't know you're being exposed
  - immediate symptoms = serious problems
- best shielding is lead, concrete or water
- easy to detect

Beta Emitters

Sample Applications	Sources
Medical	Phosphorous-32 Iodine-131
Commercial Products	Hydrogen-3 (tritium)

- most commonly effects the skin & eyes
- skin contamination can cause severe burns
- can expose even if not on skin
- best shielding is plastic
- can produce x-rays if in metal container
- harmful if inhaled or swallowed

Alpha Emitters



Sample Applications	Sources
Well Logging	Americium-241
Commercial Products	Polonium-210

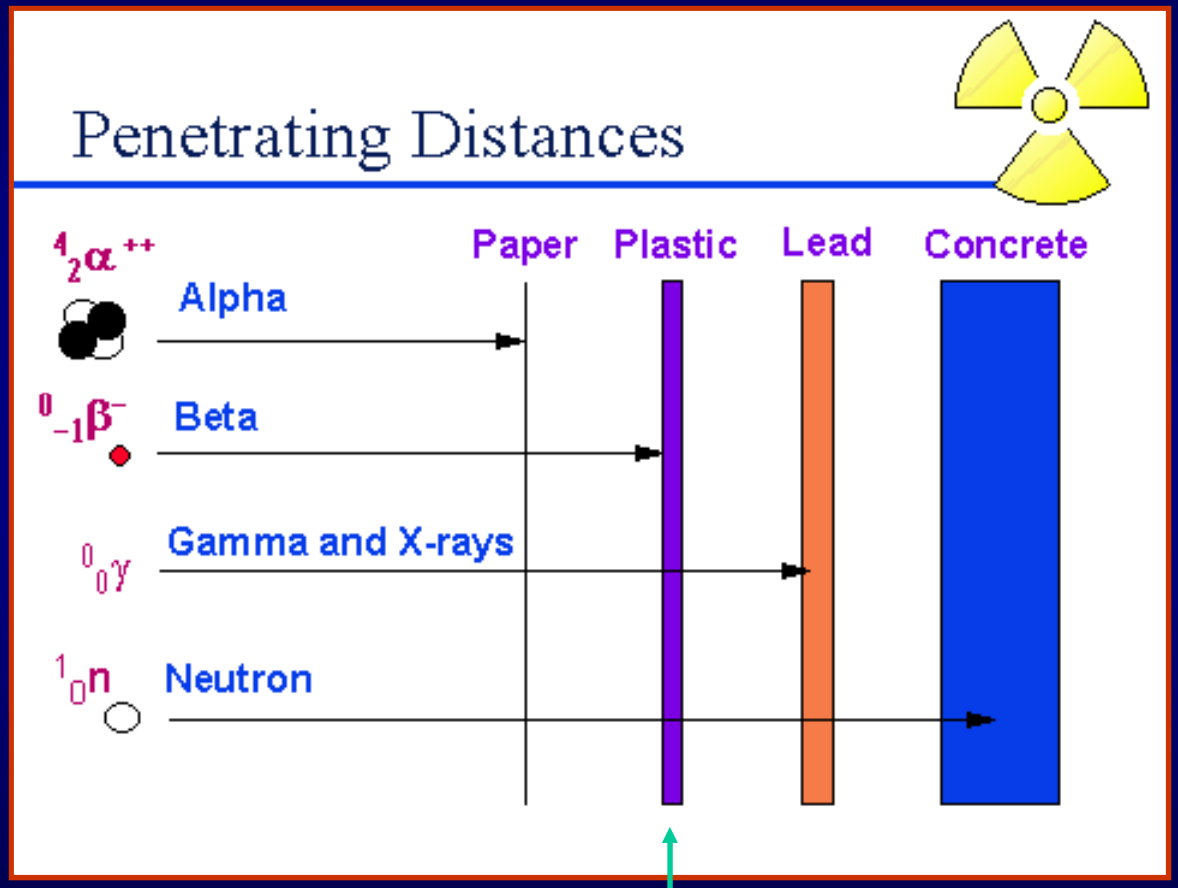
- no harm externally even if on skin
- harmful if inhaled or swallowed
  - risk of cancer in 2-20 years
- can be in powder form - easily dispersible
- shielding not required but needs to be contained
- difficult to detect - need special alpha detector - very short range so need to be close to detect it

Neutron Emitters

Sample Application	Sources
Industrial Radiography	Californium-252
Well Logging	Americum-241/Beryllium

- rare (Californium-252)
- alpha-beryllium sources (Am-Be)
- fission neutrons in nuclear power plants
- same hazards as gamma emitters
- best shielding is wax, water, plastic, boron etc
- need specialized neutron detectors
- unlikely to swallow or inhale

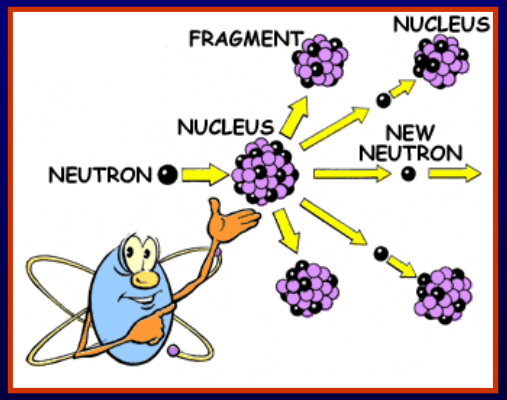
Penetration



Criticality Sources

Sample Applications	Sources
Nuclear Power	Enriched Uranium-235
Weapons Material	Enriched Uranium-235 Plutonium-239

- fissionable uranium or plutonium
- captures neutron - splits - ejects neutrons
- new radioactive sources produced
  - mostly beta, gamma emitters
- difficult to detect prior to criticality
- neutron/gamma/beta hazard



Units - SI (système international) vs Special (traditional)

ABSORBED DOSE	1 Gray (Gy) = 100 rad 1 rad = 0.01 Gy
DOSE EQUIVALENT	1 Sievert (Sv) = 100 rem 1 rem = 0.01 Sv
ACTIVITY	1 Becquerel (Bq) = 1 dps = 27 picocuries (10^{-12}) 1 Curie = 37 billion Bq

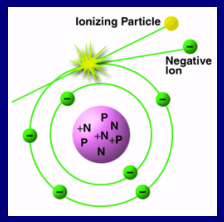
RAM Trivia

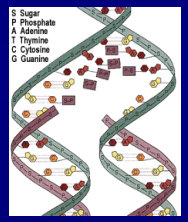
	RAM	Years until only ½ is left	Grams for 1 Curie
γ	Iridium-192	0.2	0.0001
γ	Cobalt-60	5.2	0.0009
γ	Cesium-137	30	0.0115
β	Strontium-90	29	0.0073
α	Americium-241	432	0.29
α	Thorium-232	14 billion	9 million

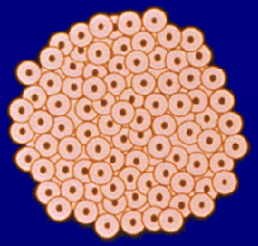
Part 2 - Biological Effects

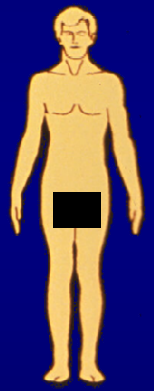
- Radiation Effects on Cells
- High Dose effects
- Low Dose Effects

The Domino Theory









Atom | Molecule | Cell | Tissue | Organ | Whole Body

Radiation ionizes atoms
(knocks out electrons)

Radiation Effects

- Death
  - Acute Radiation Syndrome (Bone Marrow, GI, Brain)
- Injury
  - cataracts, skin damage, hair loss, sterility etc
- Cancer
  - leukemia, lung, bone, breast, thyroid etc

Acute Radiation Syndrome (High Dose)

Syndrome	Threshold (rad)	Symptoms	Life Expectancy*
Bone Marrow	100	Chromosome aberrations may be seen at 20 rad but no overt clinical symptoms	2-8 wks
GI System	500	Include nausea, vomiting, and diarrhea (think FLU)	3-14 days
Central Nervous System	2,000	Include lethargy, convulsions, tremors, loss of muscle control and coma (in addition to the above effects)	<3 days

Lethal Dose - $LD_{50/30} \approx 400$ rad

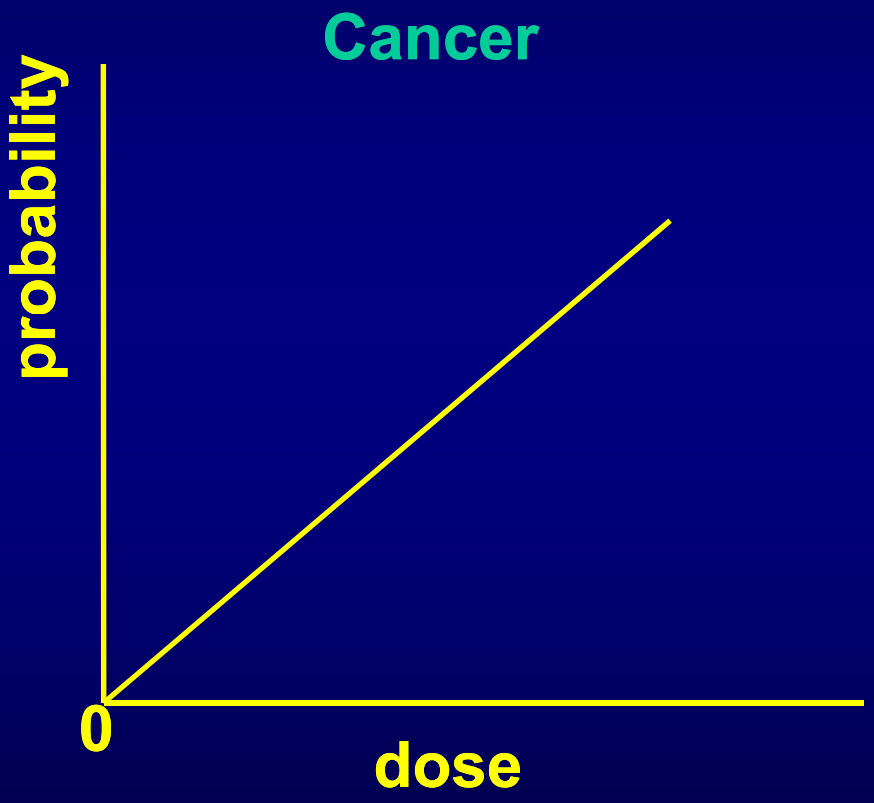
* without medical care

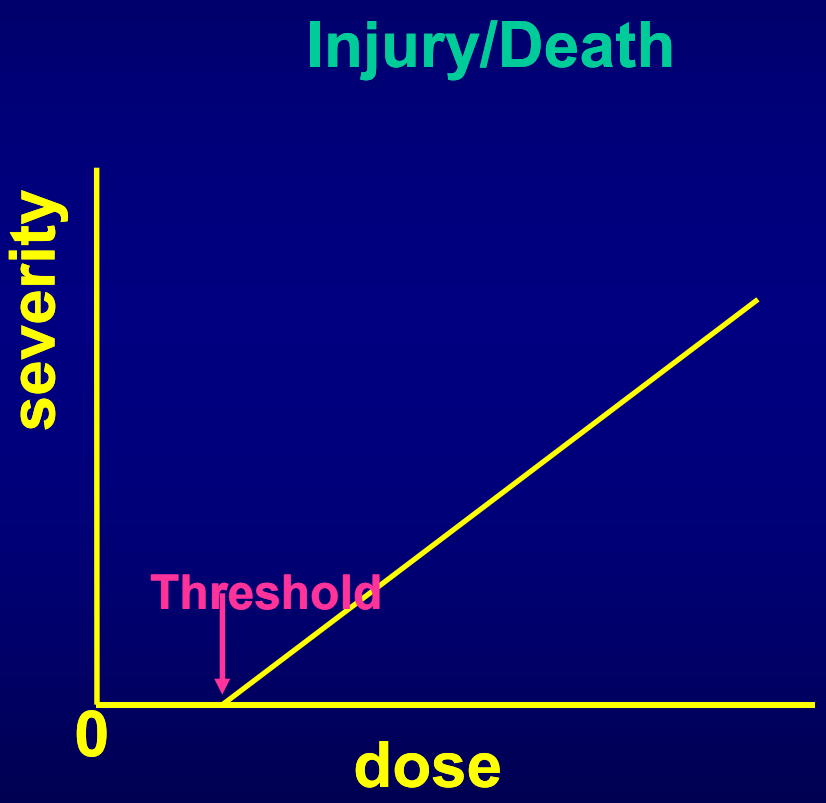
Some Non-Lethal High Dose Effects

- cataracts (~ 200 rad)
- skin damage (~ 600 rad)
- hair loss (~ 600 rad)
- sterility (~ 600 rad)

(partial body exposed - not whole body)

Dose Response Relationships

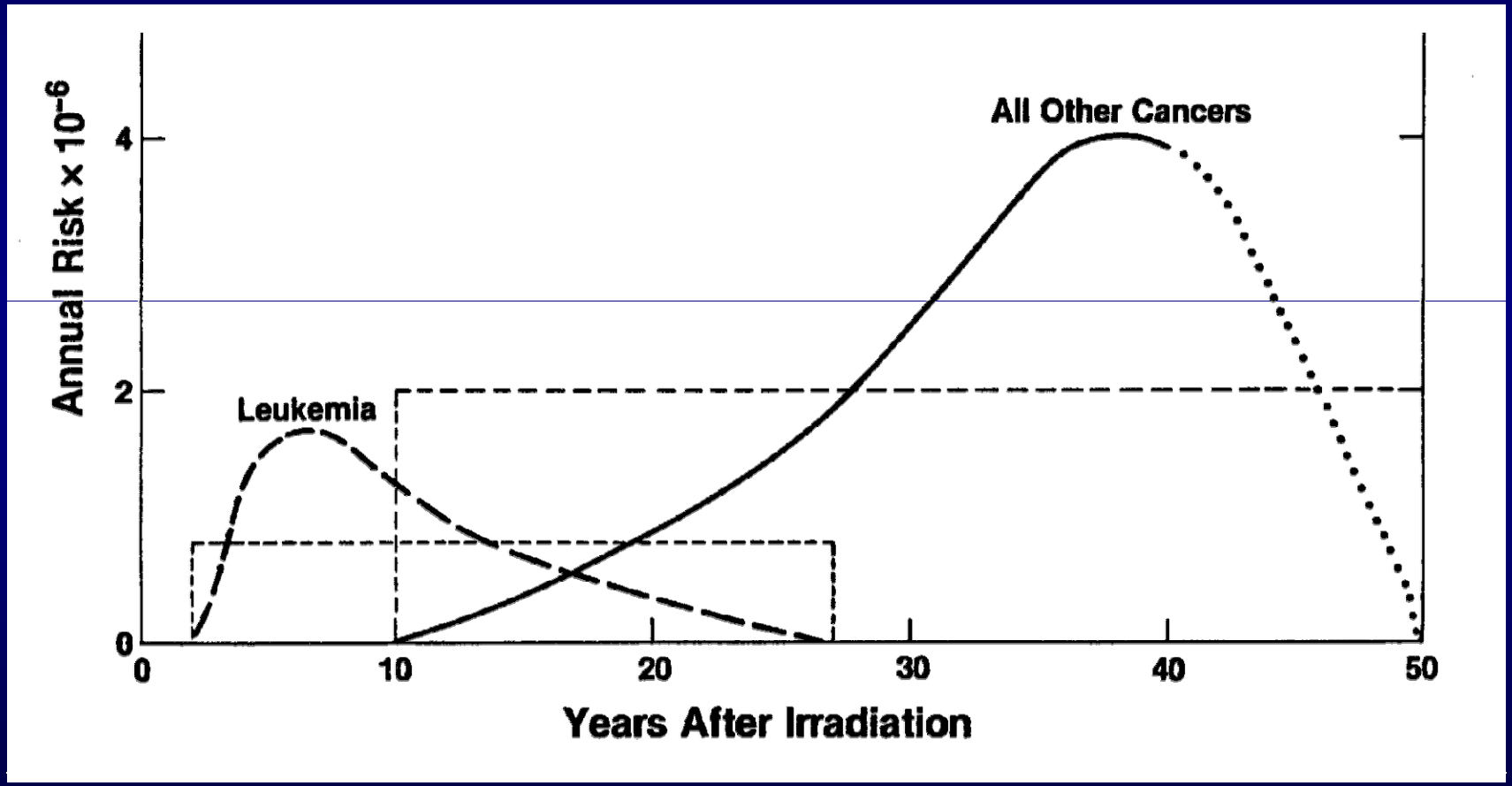




Chronic Biological Effects (Low Dose)

- **Somatic** (you exposed - you suffer)
- **Genetic** (you exposed - your children suffer)
- **In-Utero** (embryo/fetus exposed - it suffers)

Latency


Annual Risk x 10^{-6}
4
2
0
All Other Cancers
Leukemia
0
10
20
30
40
50
Years After Irradiation

Radiation Risk (Low Dose)

- Typical cancer death risk is ~ 10-20%
  - 10,000 people times 20% = 2,000 ± which is the "natural incidence"
- Radiation risk is about 0.05% or 5/10,000 per rem
- Given 10,000 people exposed to 1 rem of radiation, about 2005 ± will develop fatal cancers due to "natural incidence" plus radiation
- However, since the natural range could be anywhere between say 1,800 to 2,200, which 5 were caused by radiation?

Genetic Risks

- Ionizing radiation is known to cause inheritable mutations in many plants and animals

BUT

- Intensive studies of 70,000 offspring of the atomic bomb survivors have failed to identify an increase in congenital anomalies, cancer, etc

Part 3 – Standards and Guides

- Standards, Regulations and Guidance
- External and Internal Dose
- ALI's and DAC's
- Dose Limits
- ALARA
- Radiation Areas
- Dosimetry Records

Regulations

10 CFR Part 19	Notices, Instructions and Reports to Workers: Inspection and Investigations
10 CFR Part 20	Standards for Protection Against Radiation
MD 10.131	Protection of NRC Employees Against Ionizing Radiation

Instructions to Employees
(MD 10.131)

…. employees ….. shall be advised and instructed about:

- the hazards of exposure to radioactive materials and radiation, how to minimize exposure and how protective devices are to be used
- the responsibility to promptly report any condition that may cause unnecessary exposure to radiation or to radioactive material
- the response to radiation warnings
- the results of monitoring on an annual basis

NRC Regulatory Guides

Revision 3
JUNE 1999

U.S. Nuclear Regulatory Commission

REGULATORY GUIDE

Office of Nuclear Regulatory Research

REGULATORY GUIDE 8.13
(Draft was issued as DG-8014)

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

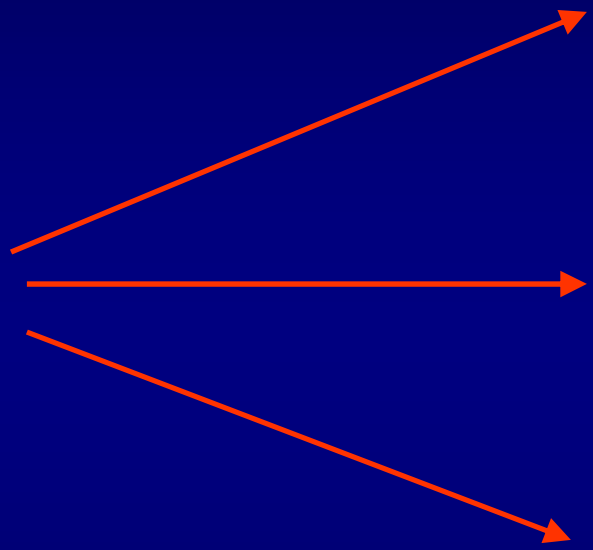
The Code of Federal Regulations in 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations," in Section 19.12, "Instructions to Workers," requires instruction in "the health protection problems associated with exposure to radiation and/or radioactive material, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed." The instructions must be "commensurate with potential radiological health protection problems present in the work place."

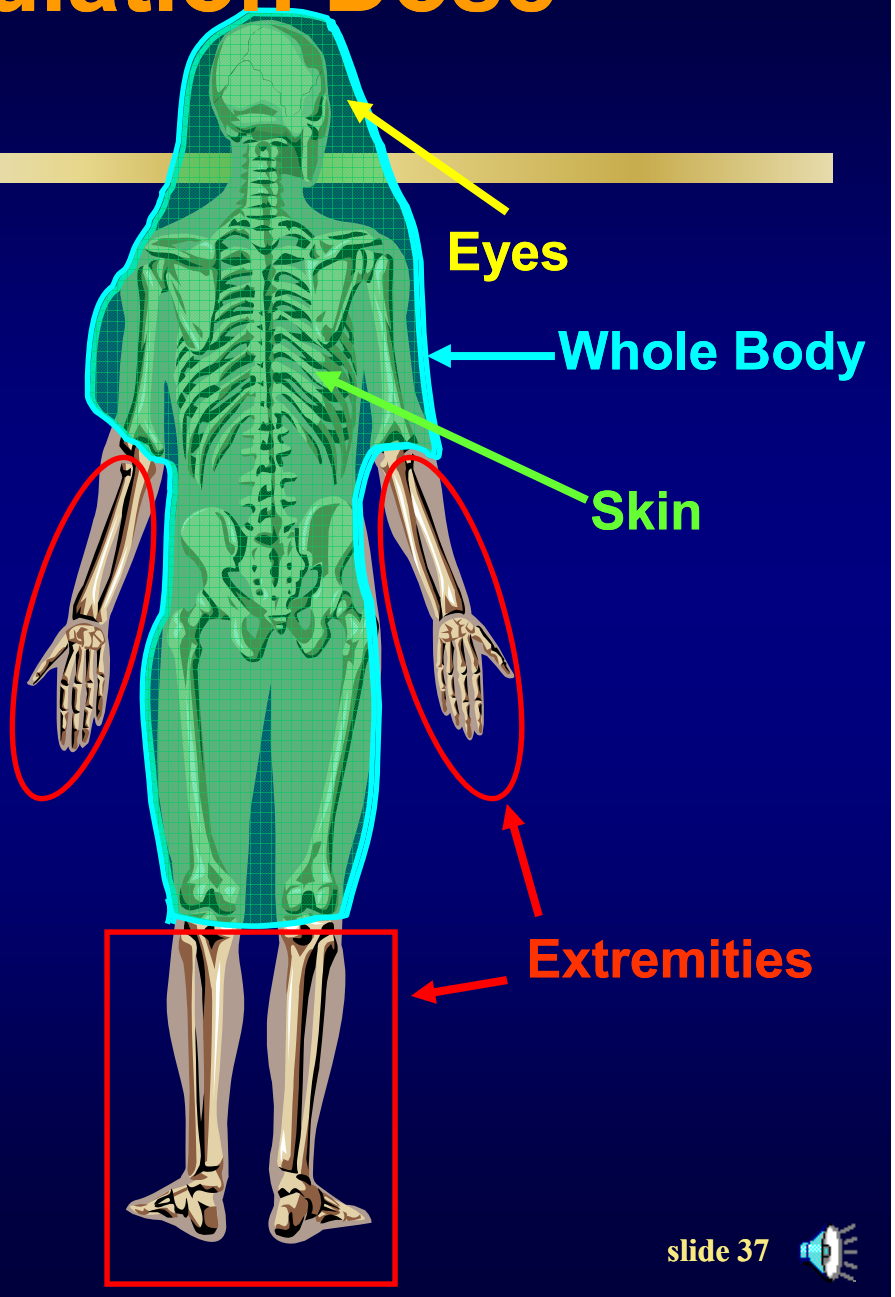
The Nuclear Regulatory Commission's (NRC's) regulations on radiation protection are specified in 10 CFR Part 20, "Standards for Protection Against Radiation"; and 10 CFR 20.1208, "Dose to an Embryo/Fetus," requires licensees to "ensure that the dose to an embryo/fetus during the entire pregnancy, due to occupational exposure of a declared pregnant woman, does not exceed 0.5 rem (5 mSv)." Section 20.1208 also requires licensees to "make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman." A declared pregnant woman is defined in 10 CFR 20.1003 as a woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

This regulatory guide is intended to provide information to pregnant women, and other personnel, to help them make decisions regarding radiation exposure during pregnancy. This Regulatory Guide 8.13 supplements Regulatory Guide 8.29, "Instruction Concerning Risks from Occupational Radiation Exposure" (Ref. 1), which contains a broad discussion of the risks from exposure to ionizing radiation.

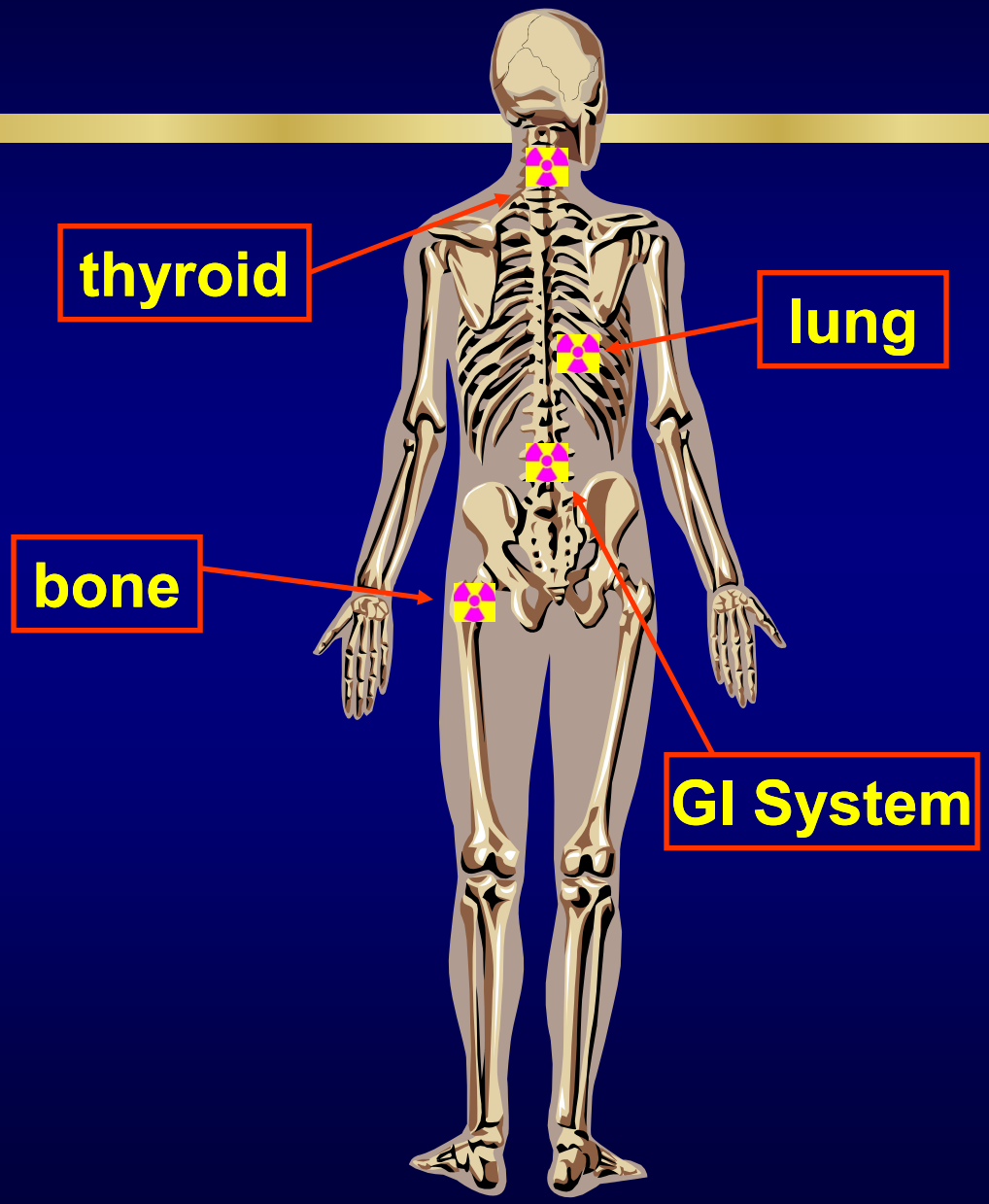
Other sections of the NRC's regulations also specify requirements for monitoring external and internal occupational dose to a declared pregnant woman. In 10 CFR 20.1502, "Conditions Requiring Individual Monitoring of External and Internal Occupational Dose," licensees are required to monitor the occupational dose to a declared pregnant woman, using an individual monitoring device, if it is likely that the declared pregnant woman will receive, from external sources, a deep dose equivalent in excess of 0.1 rem (1 mSv). According to Paragraph (e) of 10 CFR 20.2106, "Records of Individual Monitoring Results," the licensee must maintain

External Radiation Dose

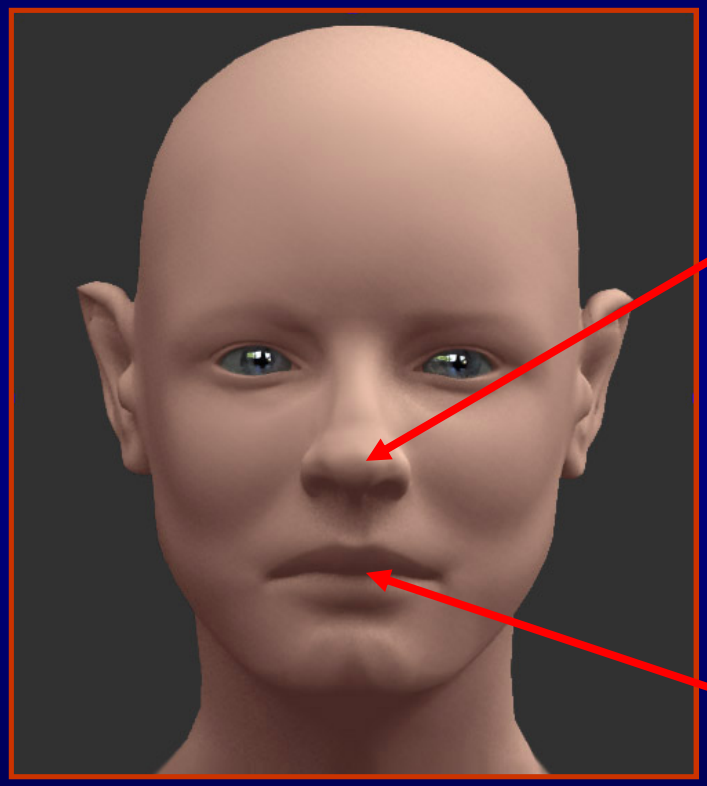




Internal Radiation Dose



ALI & DAC



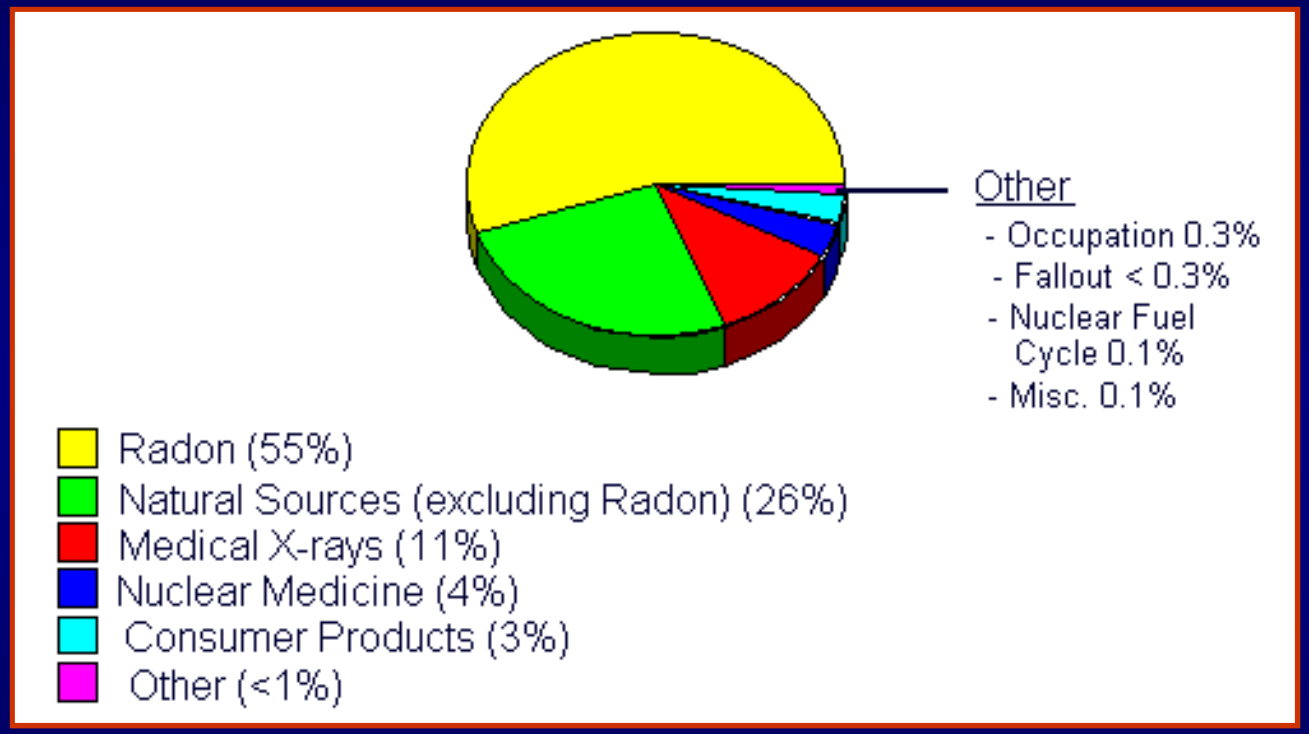
Inhalation
ALI (Annual Limit on Intake)
DAC (Derived Air Concentration)

Ingestion
ALI (Annual Limit on Intake)

Dose Limits

Occupational Dose	rem/year
Whole Body (TEDE)	5
Eyes (LDE)	15
Extremities (SDE_{ME})	50
Skin (SDE_{WB})	50
Specific Organ (TODE)	50
Minor (<18)	0.5
E/F of DPW	0.5
Non-Occupational Dose	
Public	0.1

Average Annual Population Dose

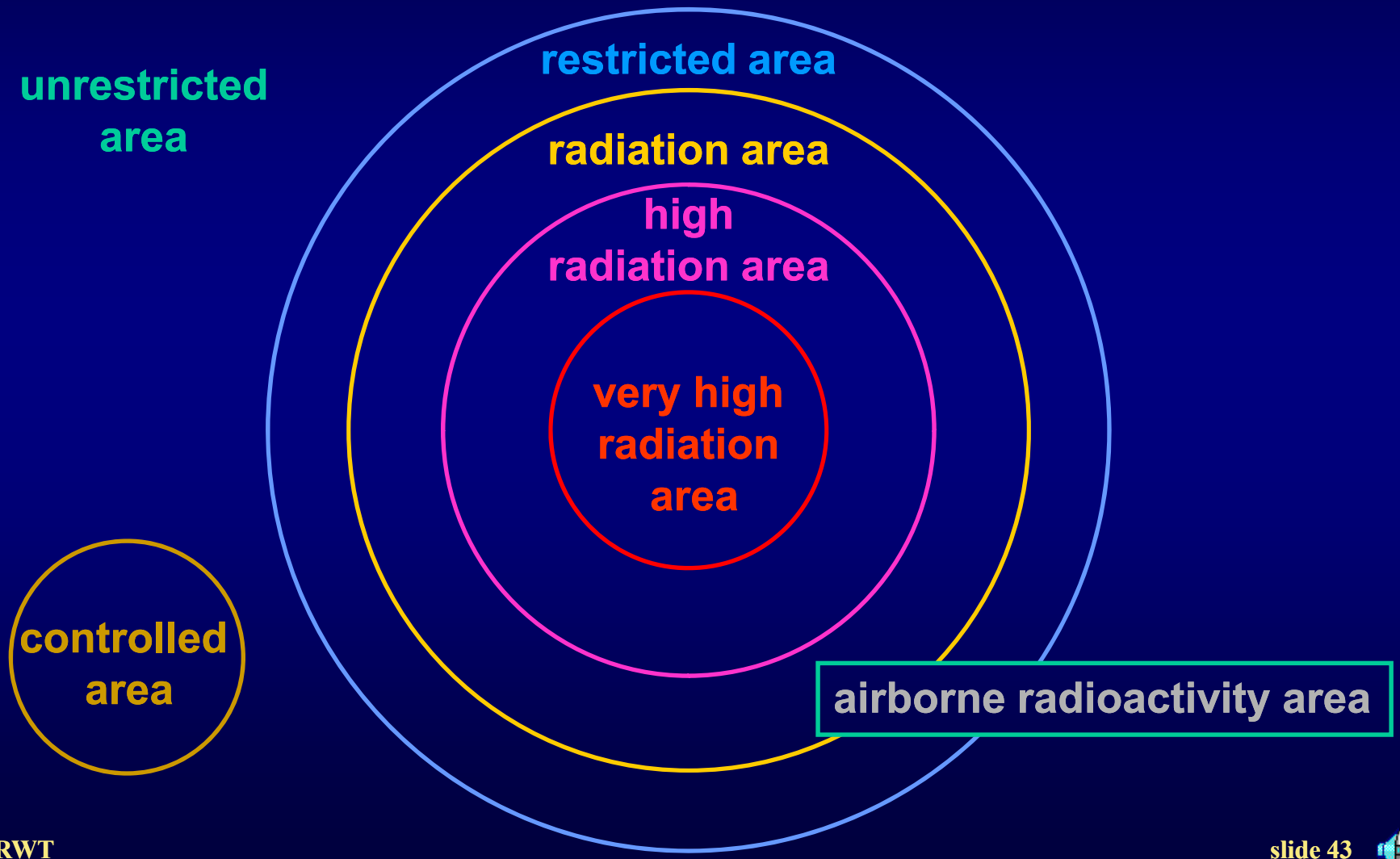


Total = 360 mrem or about 1 mrem per day

Emergency Situations
(MD 10.131)

Limit (rem)	Activity	When
5	All	Each Year
10	Protect valuable property	Lower dose not practicable
25	Lifesaving or protecting large populations	Lower dose not practicable
>25	Lifesaving or protecting large populations	Voluntary and aware of risks

Areas


unrestricted area
restricted area
radiation area
high radiation area
very high radiation area
controlled area
airborne radioactivity area

NRC Form 3

NRC FORM 3
(5-2005)
Part 1

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, DC 20555-0001

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

WHAT IS THE NUCLEAR REGULATORY COMMISSION?

The Nuclear Regulatory Commission is an independent Federal regulatory agency responsible for licensing and inspecting nuclear power plants and other commercial uses of radioactive materials.

WHAT DOES THE NRC DO?

The NRC's primary responsibility is to ensure that workers and the public are protected from unnecessary or excessive exposure to radiation and that nuclear facilities, including power plants, are constructed to high quality standards and operated in a safe and secure manner. The NRC does this by establishing requirements in Title 10 of the Code of Federal Regulations (10 CFR) and in licenses issued to nuclear users.

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?

Any company that conducts activities licensed by the NRC must comply with the NRC's requirements. If a company violates NRC requirements, it can be fined or have its license modified, suspended or revoked.

Your employer must tell you which NRC radiation requirements apply to your work and must post NRC Notices of Violation involving radiological working conditions.

WHAT IS MY RESPONSIBILITY?

For your own protection and the protection of your co-workers, you should know how NRC requirements relate to your work and should obey them. If you observe violations of the requirements or have a safety concern, you should report them.

WHAT IF I CAUSE A VIOLATION?

If you engaged in deliberate misconduct that may cause a violation of the NRC requirements, or would have caused a violation if it had not been detected, or deliberately provided inaccurate or incomplete information to either the NRC or to your employer, you may be subject to enforcement action. If you report such a violation, the NRC will consider the circumstances surrounding your reporting in determining the appropriate enforcement action, if any.

HOW DO I REPORT VIOLATIONS AND SAFETY CONCERNS?

If you believe that violations of NRC rules or the terms of the license have occurred, or if you have a safety concern, you should report them immediately to your supervisor. You may report violations or safety concerns directly to the NRC. However, the NRC encourages you to raise your concerns with the licensee since it is the licensee who has the primary responsibility for, and is most able to ensure, safe operation of nuclear facilities. If you choose to report your concern directly to the NRC, you may report this to an NRC inspector or call or write to the NRC Regional Office serving your area. If you send your concern in writing, it will assist the NRC in protecting your identity if you clearly state in the beginning of your letter that you have a safety concern or that you are submitting an allegation. The NRC's toll-free SAFETY HOTLINE for reporting safety concerns is listed below. The addresses for the NRC Regional Offices and the toll-free telephone numbers are also listed below. You can also e-mail safety concerns to allegation@nrc.gov.

WHAT IF I WORK WITH RADIOACTIVE MATERIAL OR IN THE VICINITY OF A RADIOACTIVE SOURCE?

If you work with radioactive materials or near a radiation source, the amount of radiation exposure that you are permitted to receive may be limited by NRC regulations. The limits on exposure for workers at NRC licensed facilities whose duties involve exposure to radiation are contained in sections 20.1201, 20.1207, and 20.1208 of Title 10 of the Code of Federal Regulations (10 CFR 20) depending on the part of the regulations to which your employer is subject. While these are the maximum allowable limits, your employer should also keep your radiation exposure as far below those limits as is "reasonably achievable."

MAY I GET A RECORD OF MY RADIATION EXPOSURE?

Yes. Your employer is required to advise you of your dose annually if you are exposed to radiation for which monitoring was required by NRC. In addition, you may request a written report of your exposure when you leave your job.

HOW ARE VIOLATIONS OF NRC REQUIREMENTS IDENTIFIED?

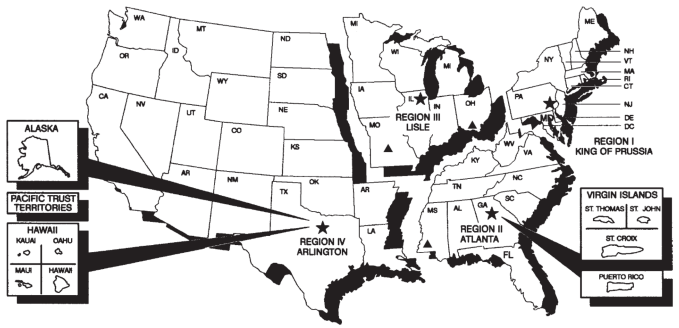
NRC conducts regular inspections at licensed facilities to assure compliance with NRC requirements. In addition, your employer and site contractors may conduct their own inspections to assure compliance. All inspectors are protected by Federal law. Interference with them may result in criminal prosecution for a Federal offense.

MAY I TALK WITH AN NRC INSPECTOR?

Yes. NRC inspectors want to talk to you if you are worried about radiation safety or have other safety concerns about licensed activities, such as the quality of construction or operations at your facility. Your employer may not prevent you from talking with an inspector. The NRC will make all reasonable efforts to protect your identity where appropriate and possible.

MAY I REQUEST AN INSPECTION?

Yes. If you believe that your employer has not corrected violations involving radiological working conditions, you may request an inspection. Your request should be addressed to the nearest NRC Regional Office and must describe the alleged violation in detail. It must be signed by you or your representative.



▲ - Callaway Plant Site in Missouri and Grand Gulf Plant Site in Mississippi are under the purview of Region IV. The Portsmouth Gaseous Diffusion Plant in Ohio is under the purview of Region II.

NRC FORM 3
5-2005)
Part 2

HOW DO I CONTACT THE NRC?

Talk to an NRC inspector on-site or call or write to the nearest NRC Regional Office in your geographical area (see map below). If you call the NRC's toll-free SAFETY HOTLINE during normal business hours, your call will automatically be directed to the NRC Regional Office for your geographical area. If you call after normal business hours, your call will be directed to the NRC's Headquarters Operations Center, which is manned 24 hours a day. You can also e-mail safety concerns to allegation@nrc.gov.

CAN I BE FIRED FOR RAISING A SAFETY CONCERN?

Federal law prohibits an employer from firing or otherwise discriminating against you for bringing safety concerns to the attention of your employer or the NRC. You may not be fired or discriminated against because you engage in certain protected activities, including but not limited to,

- ask the NRC to enforce its rules against your employer;
- refuse to engage in activities which violate NRC requirements;
- provide information or are about to provide information to the NRC or your employer about violations of requirements or safety concerns;
- are about to ask for, or testify, help, or take part in an NRC, Congressional, or any Federal or State proceeding.

WHAT FORMS OF DISCRIMINATION ARE PROHIBITED?

It is unlawful for an employer to fire you or discriminate against you with respect to pay, benefits, or working conditions because you help the NRC or raise a safety issue or otherwise engage in protected activities. Violations of Section 211 of the Energy Reorganization Act (ERA) of 1974 (42 U.S.C. 5851) include actions such as harassment, blacklisting, and intimidation by employers of (i) employees who bring safety concerns directly to their employers or to the NRC; (ii) employees who have refused to engage in an unlawful practice, provided that the employee has identified the illegality to the employer; (iii) employees who have testified or are about to testify before Congress or in any Federal or State proceeding regarding any provision (or proposed provision) of the ERA or the Atomic Energy Act (AEA) of 1954; (iv) employees who have commenced or caused to be commenced a proceeding for the administration or enforcement of any requirement imposed under the ERA or AEA or who have, or are about to, testify, assist, or participate in such a proceeding.

HOW DO I FILE A DISCRIMINATION COMPLAINT?

If you believe that you have been discriminated against for bringing violations or safety concerns to the NRC or your employer, you may file a complaint with the NRC, the U.S. Department of Labor (DOL), or appropriate state entities. If you desire a personal remedy, you must file a complaint with the DOL pursuant to Section 211 of the ERA or with appropriate state entities. Your complaint to the DOL must describe in detail the basis for your belief that the employer discriminated against you on the basis of your protected activity, and it must be filed in writing either in person or by mail within 180 days of the discriminatory occurrence. Additional information is available at the DOL web site at www.osha.gov. Filing an allegation, complaint, or request for action with the NRC does not extend the requirement to file a complaint with the DOL within 180 days. To do so, you may contact the Allegation Coordinator in the appropriate NRC Region, as listed below, who will provide you with the address and telephone number of the correct OSHA Regional office to receive your complaint. You may also check your local telephone directory under the U.S. Government listings for the address and telephone number of the appropriate OSHA Regional office.

WHAT CAN THE DEPARTMENT OF LABOR DO?

If your complaint involves a violation of Section 211 of the ERA by your employer, it is the DOL, NOT THE NRC, that provides the process for obtaining a personal remedy. The DOL will notify your employer that a complaint has been filed and will investigate your complaint.

If the DOL finds that your employer has unlawfully discriminated against you, it may order that you be reinstated, receive back pay, or be compensated for any injury suffered as a result of the discrimination and be paid attorney's fees and costs.

Relief will not be awarded to employees who engage in deliberate violations of the Energy Reorganization Act or the Atomic Energy Act.

WHAT WILL THE NRC DO?

The NRC will evaluate each allegation of harassment, intimidation, or discrimination to determine whether sufficient information exists to initiate an investigation. Following this evaluation, an investigator from the NRC's Office of Investigations may interview you and review available documentation. Based on the evaluation, and, if applicable, the interview, the NRC will assign a priority and a decision will be made whether to pursue the matter further through an investigation. The assigned priority is based on the specifics of the case. The NRC may not pursue an investigation of low priority cases to the point that a conclusion can be made whether the harassment, intimidation, or discrimination actually occurred. If you do not object, the NRC may refer lower priority cases to the involved licensee for a response and will request that the licensee independently review such issues. Even if NRC decides not to pursue an investigation, if you have filed a complaint with the DOL, the NRC will monitor the results of the DOL investigation.

If the NRC or the DOL finds that unlawful discrimination has occurred, the NRC may issue a Notice of Violation to your employer, impose a fine, or suspend, modify, or revoke your employer's NRC license.

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

A representative of the Nuclear Regulatory Commission can be contacted by employees who wish to register complaints or concerns about radiological working conditions or other matters regarding compliance with Commission rules and regulations at the following addresses and telephone numbers.

REGIONAL OFFICES

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission, Region I 475 Allendale Road King of Prussia, PA 19406-1415	(800) 432-1156
II	U.S. Nuclear Regulatory Commission, Region II Sam Nunn Atlanta Federal Center 61 Forsyth Street, S.W., Suite 23T85 Atlanta, GA 30303-8931	(800) 577-8510
III	U.S. Nuclear Regulatory Commission, Region III 2443 Warrenville Road, Suite 210 Lisle, IL 60532-4352	(800) 522-3025
IV	U.S. Nuclear Regulatory Commission, Region IV 611 Ryan Plaza Drive, Suite 400 Arlington, TX 76011-4005	(800) 952-9677

To report safety concerns or violations of NRC requirements by your employer,

telephone:

NRC SAFETY HOTLINE

1-800-695-7403

To report incidents involving fraud, waste, or abuse by an NRC employee or NRC contractor,

telephone:

OFFICE OF THE INSPECTOR GENERAL HOTLINE

1-800-233-3497

NRC Form 4

PAGE ____ OF ____

NRC FORM 4
(9-2004)
10 CFR PART 20

U.S. NUCLEAR REGULATORY COMMISSION

CUMULATIVE OCCUPATIONAL DOSE HISTORY

APPROVED BY OMB NO.3150-0005 EXPIRES: 09/30/2007

Estimated burden per response to comply with this mandatory collection request: 30 minutes. This information is required to record an individual's lifetime occupational exposure to radiation to ensure that the cumulative exposure to radiation does not exceed regulatory limits. Send comments regarding burden estimate to the Records and FOIA/Privacy Services Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0005), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

1. NAME (LAST, FIRST, MIDDLE INITIAL)	2. IDENTIFICATION NUMBER	3. ID TYPE	4. SEX	5. DATE OF BIRTH (MM/DD/YYYY)
			☐ MALE ☐ FEMALE	

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)	7. LICENSEE NAME	8. LICENSE NUMBER	9.	10.
–			☐ RECORD ☐ ESTIMATE ☐ NO RECORD	☐ ROUTINE ☐ PSE

11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE	16. CDE	17. TEDE	18. TODE

(Repeated 5 times)

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)	7. LICENSEE NAME	8. LICENSE NUMBER
–		

11. DDE	12. LDE	13. SDE, WB	14. SDE, ME	15. CEDE

(Repeated 3 times)

19. SIGNATURE OF MONITORED INDIVIDUAL	20. DATE SIGNED	21. CERTIFYING ORGANIZATION

NRC FORM 4 (9-2004)

NRC Form 5

PAGE ____ OF ____

NRC FORM 5
(9-2004)
10 CFR PART 20

U.S. NUCLEAR REGULATORY COMMISSION

OCCUPATIONAL DOSE RECORD FOR A MONITORING PERIOD

APPROVED BY OMB NO.3150-0006 EXPIRES: 09/30/2007

Estimated burden per response to comply with this mandatory collection request: 20 minutes. This information is used to ensure that doses to individual do not exceed regulatory limits. This information is required to record/annually report individual occupational exposure to radiation to ensure that the exposure does not exceed regulatory limits. Send comments regarding burden estimate to the Records and FOIA/Privacy Services Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0006), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

1. NAME (LAST, FIRST, MIDDLE INITIAL)	2. IDENTIFICATION NUMBER	3. ID TYPE	4. SEX	5. DATE OF BIRTH (MM/DD/YYYY)
			☐ MALE ☐ FEMALE	

6. MONITORING PERIOD (MM/DD/YYYY - MM/DD/YYYY)	7. LICENSEE NAME	8. LICENSE NUMBER(S)	9A.	9B.
–			☐ RECORD ☐ ESTIMATE	☐ ROUTINE ☐ PSE

INTAKES				DOSES (in rem)		
10A. RADIONUCLIDE	10B. CLASS	10C. MODE	10D. INTAKE IN μCi			
				DEEP DOSE EQUIVALENT	(DDE)	11.
				LENS (EYE) DOSE EQUIVALENT	(LDE)	12.
				SHALLOW DOSE EQUIVALENT, WHOLE BODY	(SDE,WB)	13.
				SHALLOW DOSE EQUIVALENT, MAX EXTREMITY	(SDE,ME)	14.
				COMMITTED EFFECTIVE DOSE EQUIVALENT	(CEDE)	15.
				COMMITTED DOSE EQUIVALENT, MAXIMALLY EXPOSED ORGAN	(CDE)	16.
				TOTAL EFFECTIVE DOSE EQUIVALENT (ADD BLOCKS 11 AND 16)	(TEDE)	17.
				TOTAL ORGAN DOSE EQUIVALENT MAX ORGAN (ADD BLOCKS 11 AND 16)	(TODE)	18.
				19. COMMENTS		

20. SIGNATURE - LICENSEE	21. DATE PREPARED

NRC FORM 5 (9-2004)

PRINTED ON RECYCLED PAPER

Part 4 – Controlling Exposure

- Sources of Exposure
- Protection Against External Dose
- Protection Against Internal Dose
- Radiation Detection Instruments

ALARA

Stay Time

$$\text{Stay Time (hr)} = \frac{\text{Limit (mrem)}}{\text{Dose Rate (mrem/hr)}}$$

Example: How long can you remain in an area if the dose rate is 20 mrem/hr and the limit is 100 mrem?

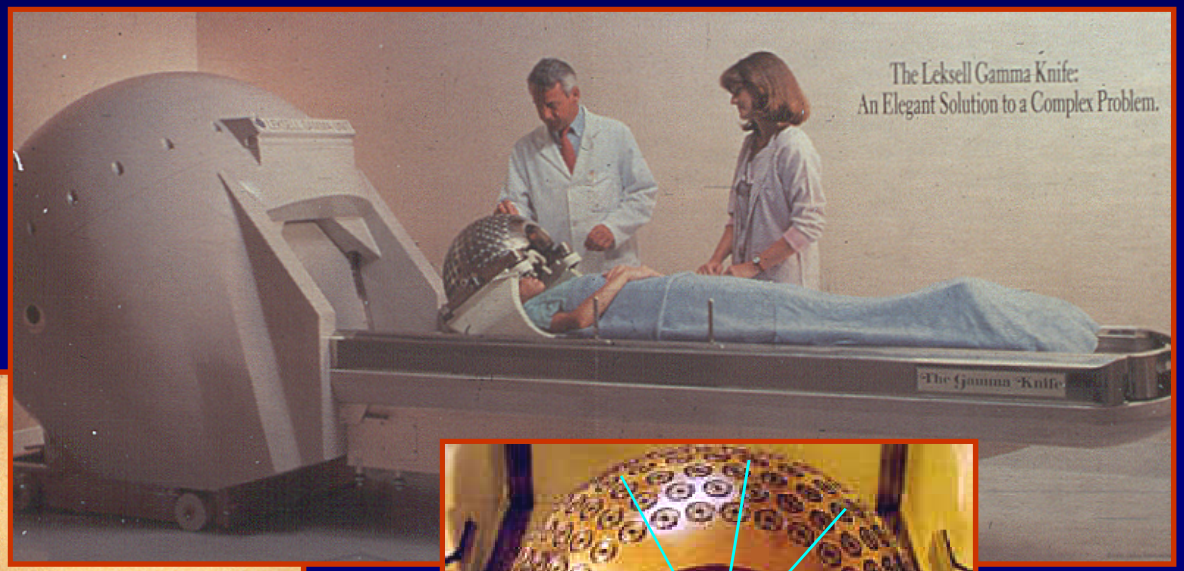
$$\text{Stay Time} = \frac{100 \text{ mrem}}{20 \text{ mrem/hr}} = 5 \text{ hrs}$$

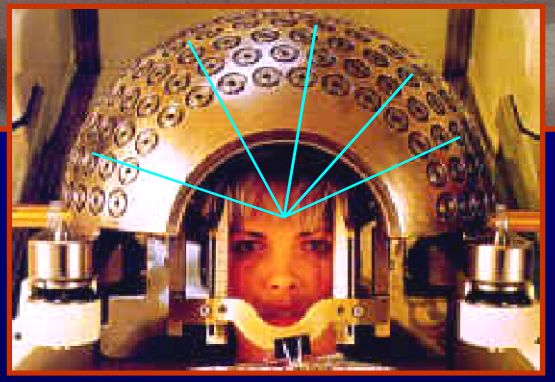
Relative External Hazard

RAM		Dose Rate at 1 meter for 1 Curie (R/hr)
γ	Iridium-192	0.47
γ	Cobalt-60	1.3
γ	Cesium-137	0.33
β	Strontium-90	N/A*
α	Americium-241	N/A
α	Thorium-232	N/A

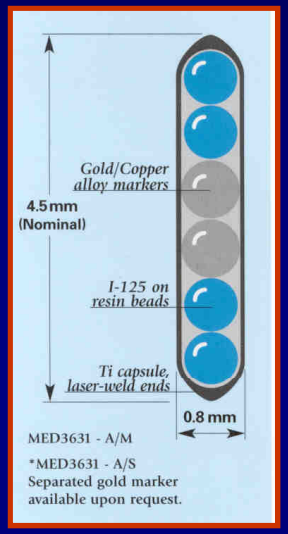
* skin/eye dose possible

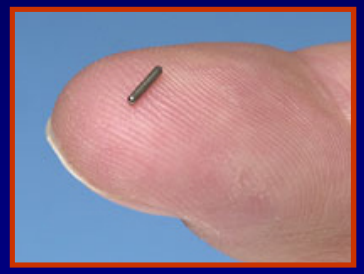
Medical
External Beam Therapy

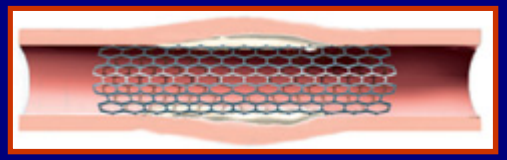




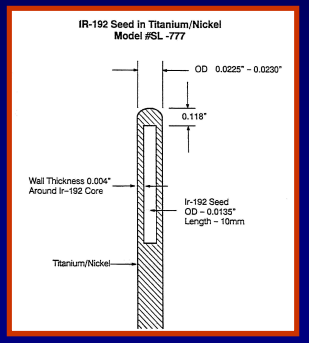
Medical Brachytherapy



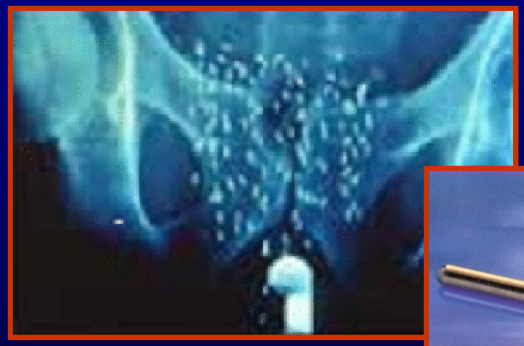




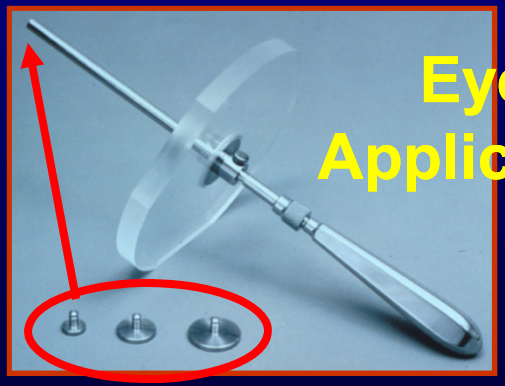
Stent



High Dose Rate



Permanent



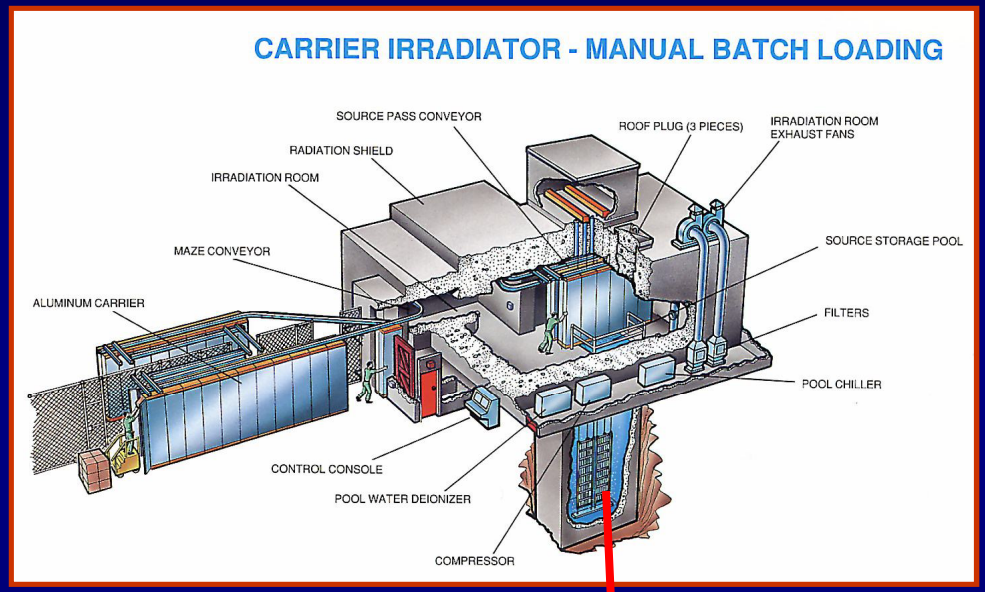
Eye Applicator

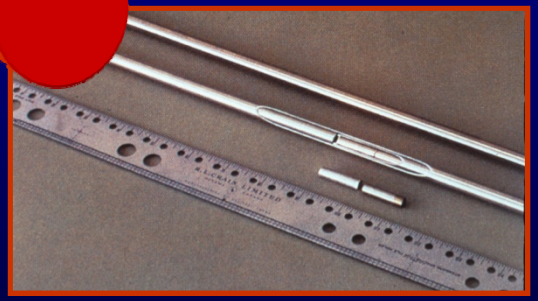
Industrial Radiography Cameras

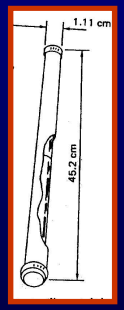
iridium-192

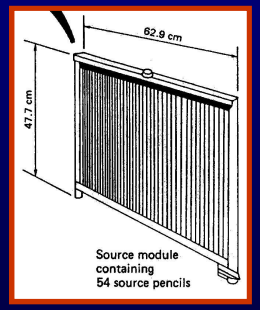
cobalt-60

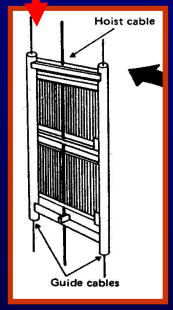
Irradiators
Pool Type and Self Shielded

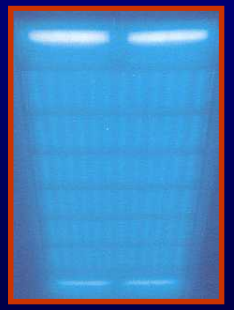




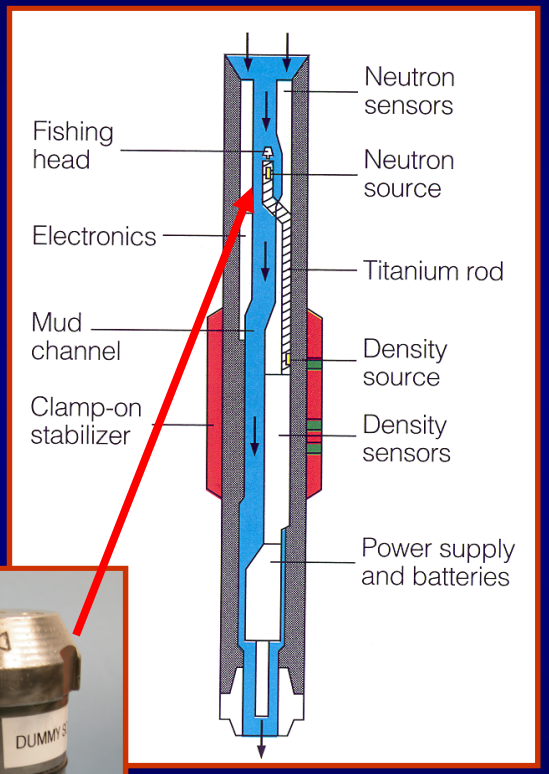




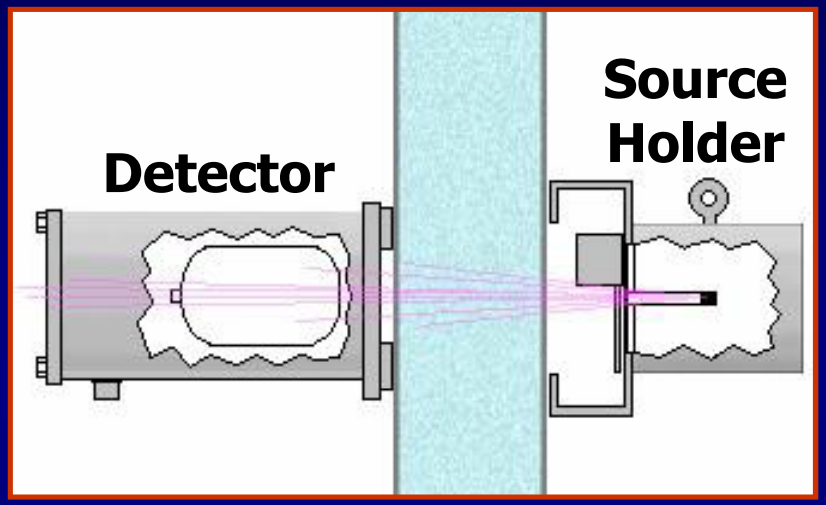


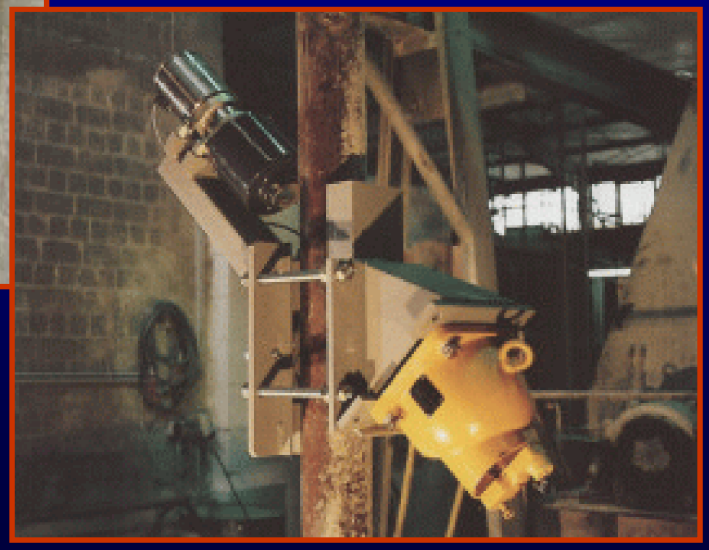


Well Logging



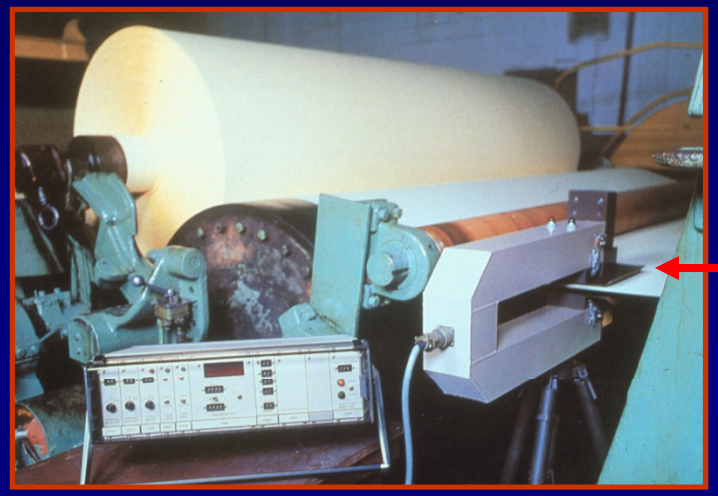
Fixed Gauges





Fixed Gauges

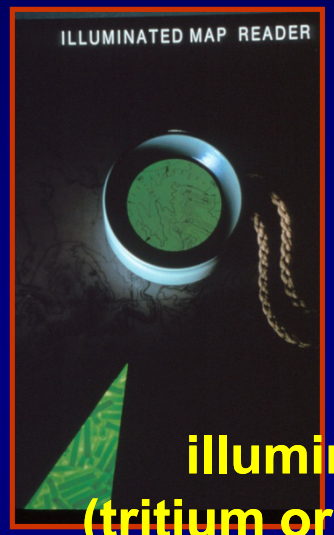
product thickness



product level

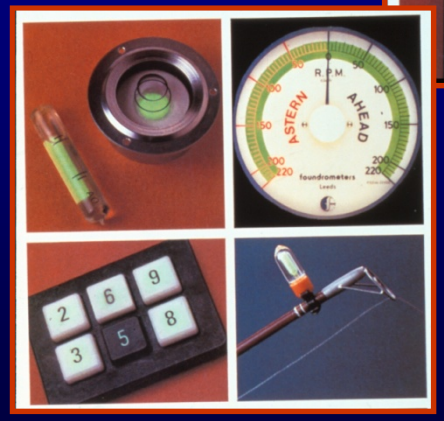
Portable Gauges

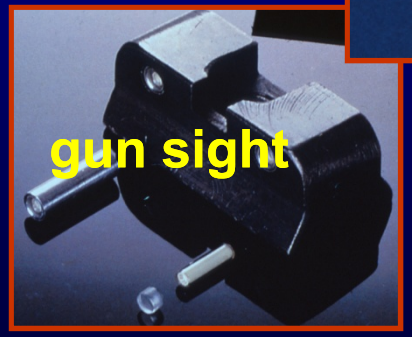
Commercial Products



illuminated devices
(tritium or promethium-147)

runway
markers
(tritium)



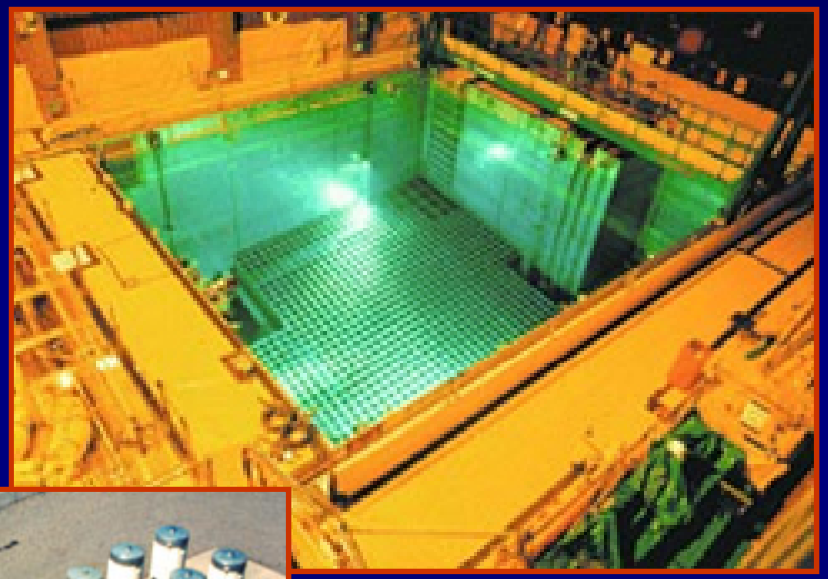


gun sight

(tritium)

bow sight

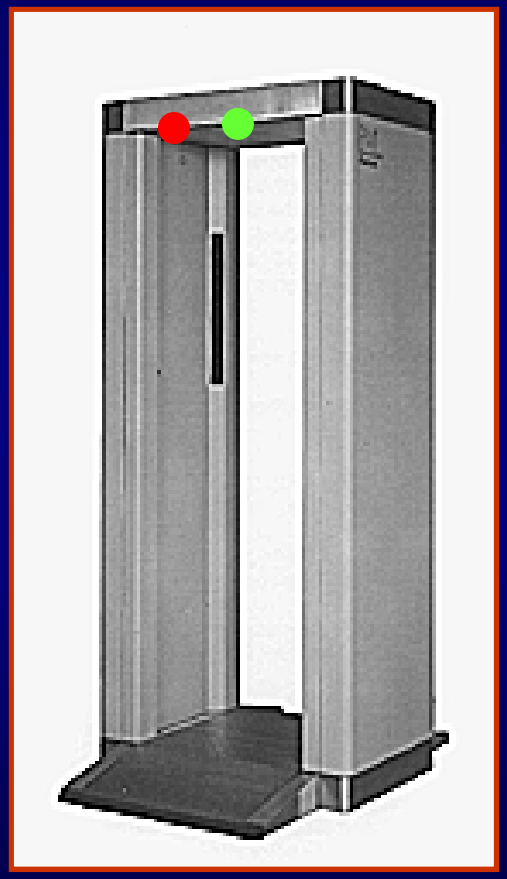
Nuclear Power



Internal Exposure Protection

- Airborne Contamination
  - Engineering controls
  - Personal Protective Equipment (PPE) - Respirators
- Surface Contamination
  - Decontamination
  - PPE

Contamination Monitoring



Walk Through Monitor

Self Frisk

Hand And Foot

Automated Personnel Contamination Monitor

Part 5 – Dose Evaluation

- External Dosimetry (Direct)
- Internal Dosimetry (Indirect)
- Dose Assessment
- Accident Review

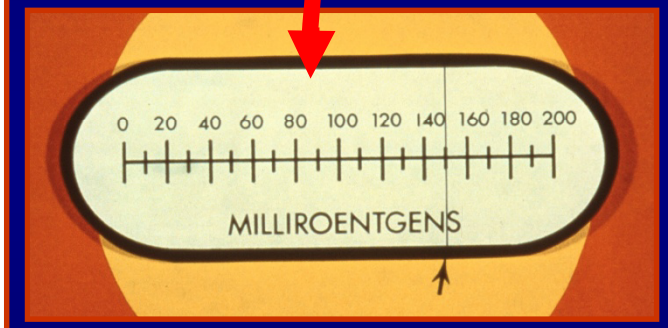
External Dosimetry Summary

- Most alpha particles cannot penetrate the protective (dead) skin layer
- Beta particles can irradiate lens of eye and skin
- Beta sources can produce x-rays as well
- In general, primary sources of external exposure are gamma rays and neutrons
- External dose must be measured by means of an appropriate dosimeter

Conditions for Monitoring NRC Employees (MD 10.131)

- An employee is likely to exceed 10 percent of any of the limits.
- A declared pregnant employee is likely to receive during the entire pregnancy, from radiation sources external to the body, a deep dose equivalent in excess of 100 mrem.
- An employee is entering a high or a very high radiation area.

Dosimeters


0 20 40 60 80 100 120 140 160 180 200
MILLIROENTGENS

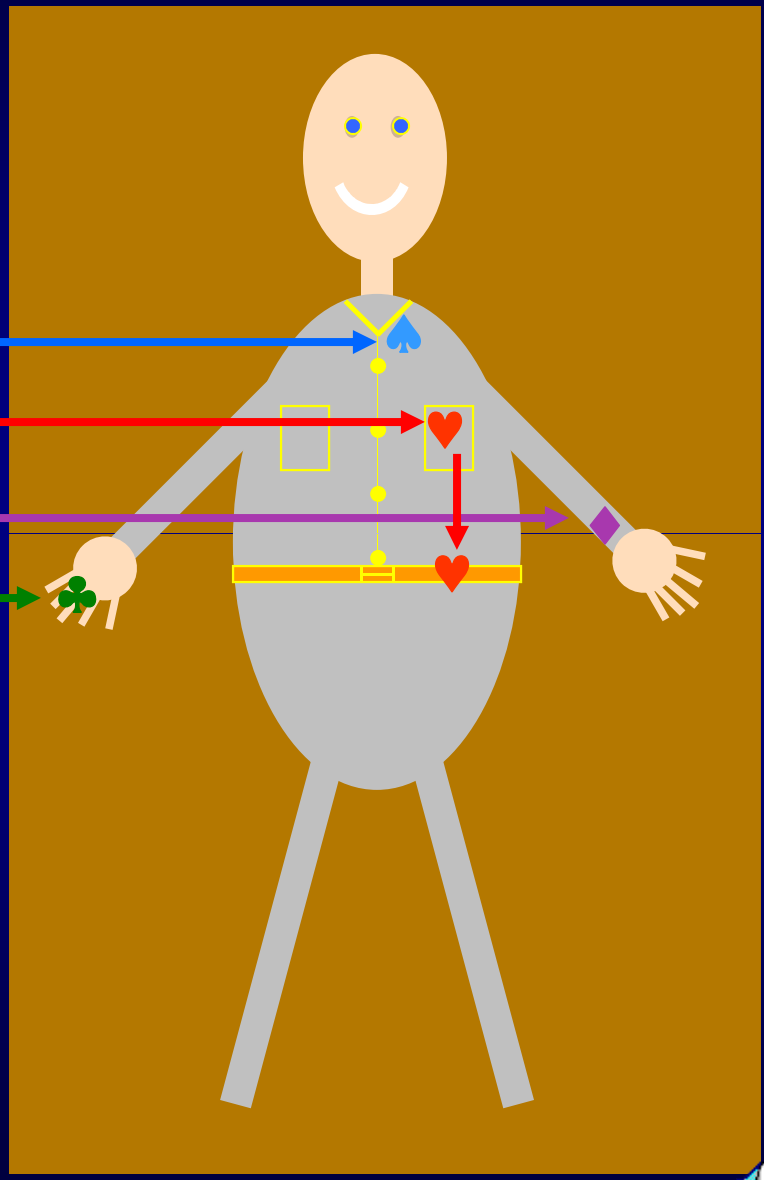

SETTING VALUE
TIME
γ+
mSv
ON
OFF
FUJI


ANTHONY
WEBSTER
RADIOLOGY
UNIVERSITY
MEDICAL CENTER
Pa
luxel+
LANDAUER


6100
DOSE
mSv/h
RATE

Dosimeter Locations

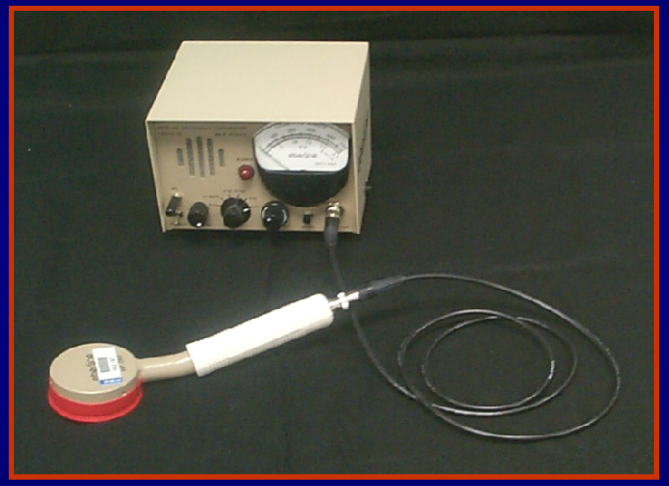
- ♠ collar
- ♥ torso (belt or shirt pocket)
- ♦ wrist
- ♣ finger



Employee Exposure Database System (EEDS)

- All NRC exposure records are maintained in the EEDS by a contractor
- The EEDS program is managed by the Office of Nuclear Regulatory Research (RES)

Survey Meters



The In's and Out's of RAM

How it gets in

inhalation
ingestion

absorption
puncture

How it gets out

urine
feces

breath
blood
nasal mucous
sputum
sweat

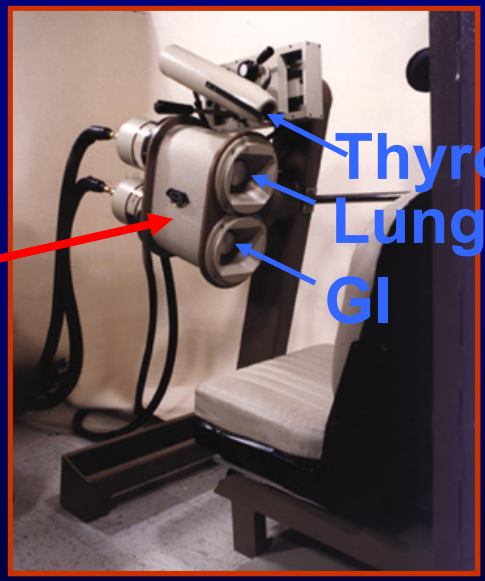
Bioassay

In-Vitro Bioassay
(Biological Sampling)

In-Vivo Bioassay

Whole Body Counting

Organ Counting



Internal Hazard

Flow Path for Evaluating the Risk

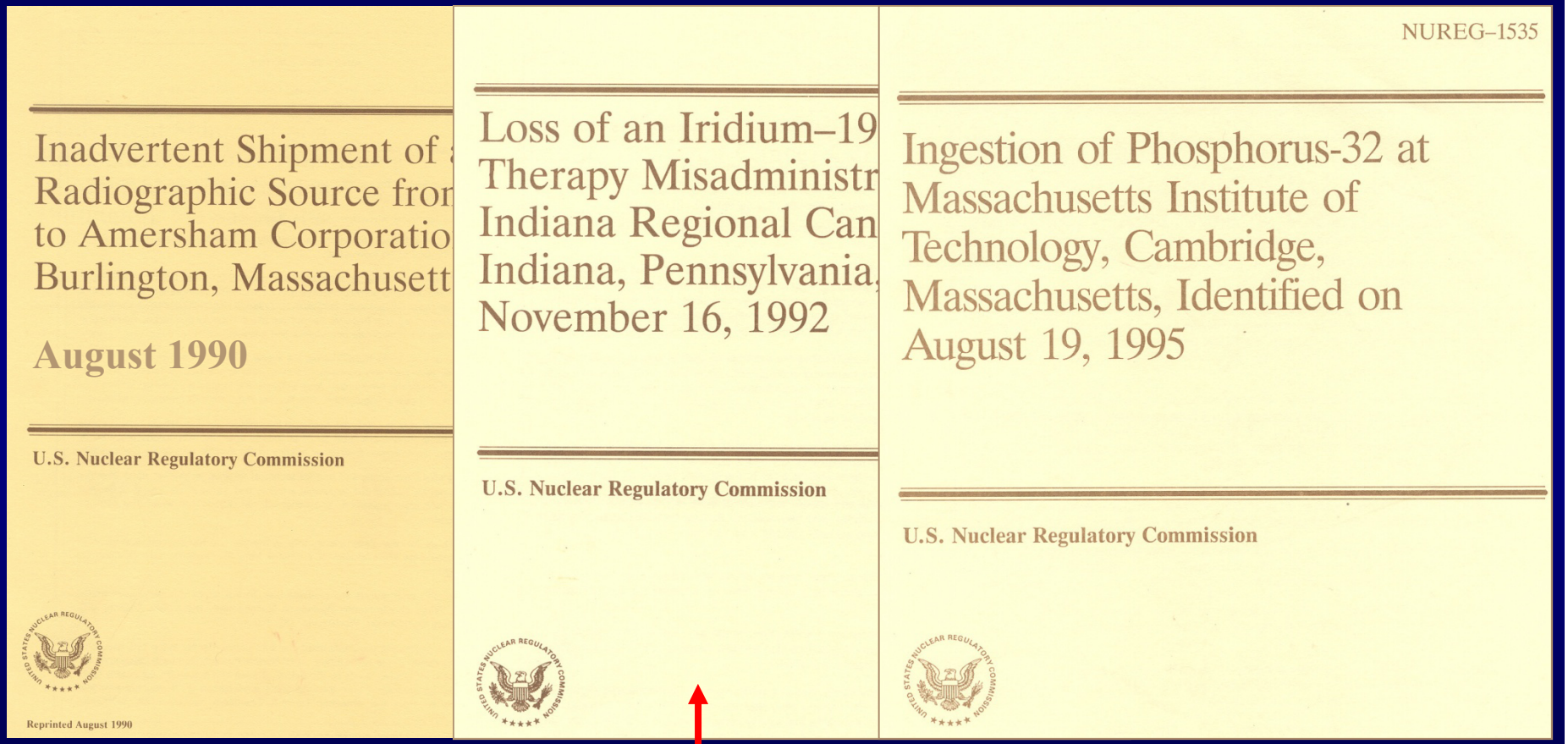
BIOASSAY	Urine (amount of RAM in sample) WBC (amount of RAM in body)
INTAKE	back calculate to determine intake
DOSE	intake compared to ALI to get dose which is related to risk

Relative Internal Hazard of Alpha, Beta and Gamma Emitters

Radionuclide	Annual Limit on Intake (ALI) (μCi) Ingestion	Inhalation
α polonium-210	3	0.6
β phosphorous-32	600	900
γ technetium-99m	80,000	200,000

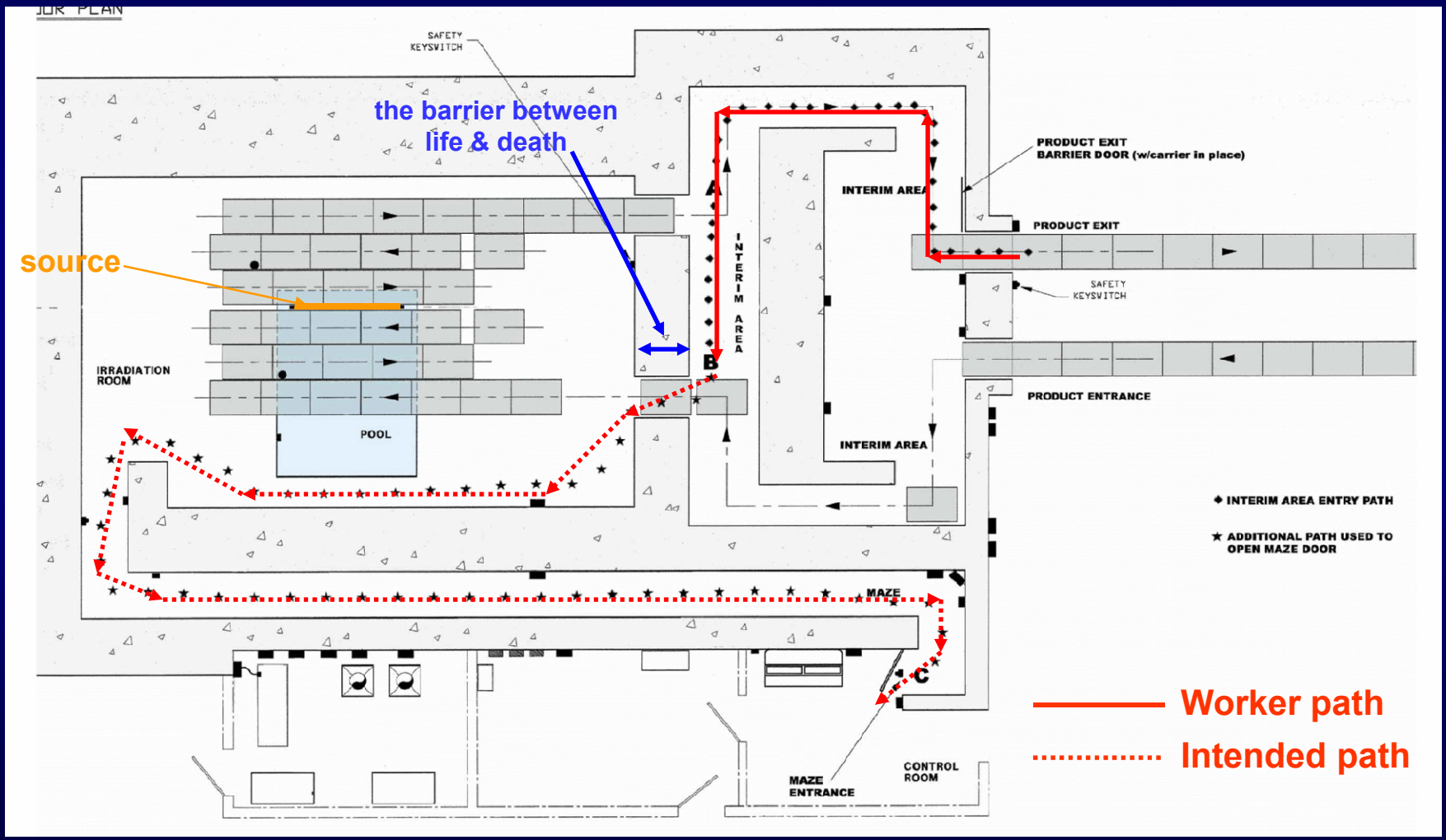
NOTE: these 3 radionuclides are essentially pure emitters

Incidents/Accidents (IIT Reports)



Fatality

Puerto Rico (2004)



Part 6 – Industrial Safety

- Non-Radiological Hazards
- OSHA - NRC MOU
- Protection Against Hazards

Relative Hazards

- Radiation
  - You are unlikely to be exposed to a lethal dose
  - You are also unlikely to be exposed to enough radiation to produce an injury such as cataracts
  - However, you may be exposed to small amounts of radiation which may slightly increase your risk of developing cancer 2-20 years from now

- Non-Radiation Hazards
  - Many of the industrial hazards listed on the following slides can kill you instantly, or, if you're lucky, they might just maim you for life

The NRC - OSHA MOU

- The NRC has a memorandum of understanding (MOU) with OSHA regarding occupational safety at licensee facilities.
- NRC personnel may identify OSHA safety concerns or may receive complaints from an employee about OSHA-covered working conditions. They may bring these matters to the attention of licensee management, or elevate these issues to the attention of the NRC Regional management when appropriate.

Chemicals

- Chemical hazards
  - carcinogens
  - corrosives
  - explosives
  - gases
  - poisons
  - solvents
  - pyrophoric metals

- MSDS = Material Safety Data Sheet

Other Hazards

- Confined spaces (e.g., large tanks) - You can pass out quickly if the oxygen level is below a minimum amount - Rescuers may also pass out - Don't enter unless you know the area has been evaluated and approved
- Compressed Gases - If a gas cylinder falls it can become a deadly missile
- Falls and other Walking Hazards - Watch where you're going

Safety Equipment

- Don't forget your
  - brain (think)
  - eyes (look)
  - ears (listen)
  - mouth (ask)
- Also, as needed:
  - hard hat
  - eye protection
  - ear protection
  - steel toed shoes

Watch for postings, tags and permit requirements

Reference

- MD 10.130 - Safety and Health Program Under the Occupational Safety and Health Act
- IN88-100 - Memorandum of Understanding Between NRC and OSHA Relating to NRC-Licensed Facilities (53 FR 43950, October 31, 1988)
- "Occupational Safety and Health Standards," 29 CFR Part 1910
- "Basic Program Elements for Federal Employee Occupational Safety and Health Programs and Related Matters," 29 CFR Part 1960

THE END