

IV. Standard Protective Measures Against Ionizing Radiation

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**Center for Medical Countermeasures
Against Radiation**



Objectives

- **Understand the principal of “ALARA”.**
- **Understand how administrative controls are useful in the protection of personnel against radiation.**
- **Learn standard procedural and engineering controls that are effective in reducing radiation exposure.**



Guiding Principals

- No unnecessary exposure to radiation.
- Principal of “ALARA”



Principle of “ALARA”

AS

Low

AS

Reasonably

Achievable

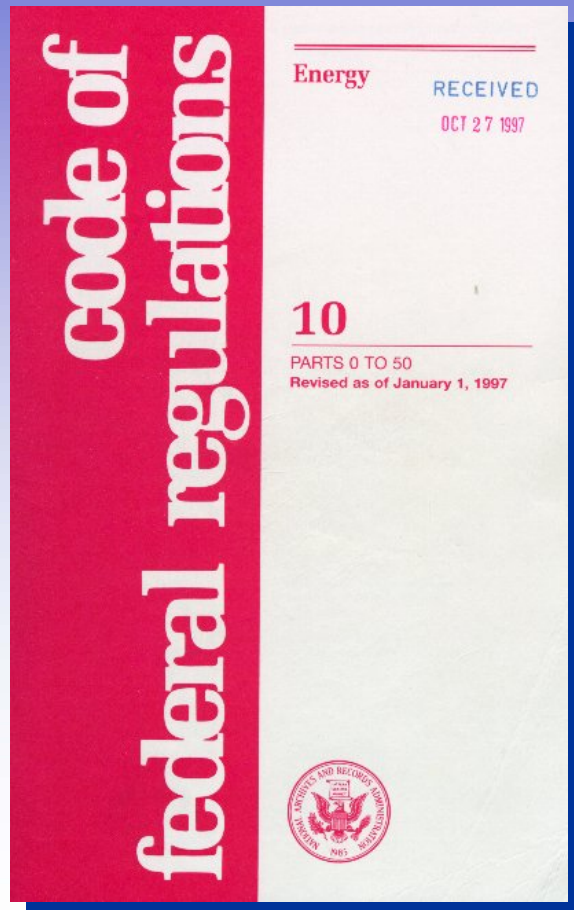


Principal of “ALARA”

- **“ALARA” policies strive to keep radiation exposure to the lowest feasible levels, within societal and economic constraints.**
- **A radiation protection program consistent with ALARA maintains radiation exposures at 10% or less of the applicable regulatory limits.**



Administrative Controls: Radiation Regulations



**Code of Federal Regulations,
Title 10, Parts 20 and 35 set
occupational dose limits
and provide for protection
of the general public.**

Annual Radiation Dose Limits

<u>Population</u>	<u>NCRP 91</u>	<u>10 CFR 20</u>
Rad. Workers	5/15/50 rem 1 x age lifetime	5/15/50 rem No Lifetime
Occasion. Exposed	0.5/5/5 rem	0.5 rem
Gen. Public	0.5/5/5 rem	0.1 rem
Minor Trainees	0.1 rem	0.5 rem
Fetus	0.5 rem 50 mrem / month	0.5 rem No monthly limit



Occupational Exposure Does NOT Include:

- **Natural background radiation / radon.**
- **Medical x-rays or nuclear medicine studies.**
- **Anything else not directly consequential to employment or to activities of regulated licensees.**



Administrative Controls: Posting



> 5 mrem/hr



> 100 mrem/hr



> 500 rem/hr



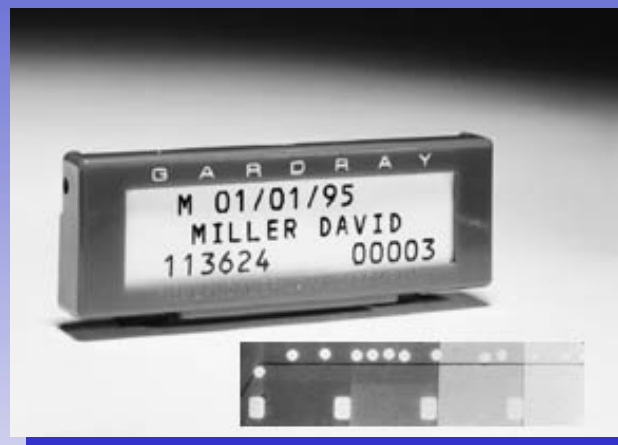
**Depends on radionuclide: > 10 mCi
H-3, 1 mCi S-35, 0.1 mCi P-32,
0.001 mCi I-125**



External Radiation Dosimetry

- Accomplished by wearing “personal dosimeters” on the body surface.
- Dosimeter measures the dose to the dosimeter, not to the individual wearing it.
- Dose to personnel must be estimated from the dosimeter’s reading.

External Radiation Dosimetry





Internal Radiation Dosimetry

- **“Bioassays” can provide important physiological information for internal dosimetric purposes:**
 - **Assay of thyroid radioactivity (radioiodine)**
 - **Urine assay (tritium, heavy metals)**
 - **Total body counting (limited availability)**



Procedural Controls

- Individuals can limit exposure to radiation by modifying the way they work around radiation sources or radioactive materials.
- The major procedural controls against radiation are time, distance and shielding.



Time - Distance - Shielding

- Total exposure is the product of exposure rate and time
- Therefore, reduction in time of exposure reduces total exposure and consequently total absorbed dose
- SO...work quickly but safely



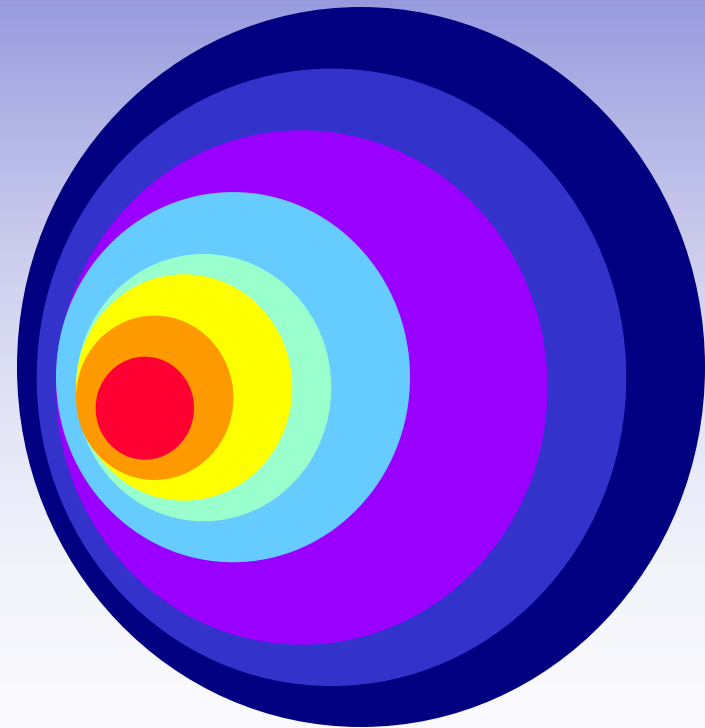
Time - Distance - Shielding

1 meter: 16.0 mR / hr

2 meters: 4.0 mR / hr

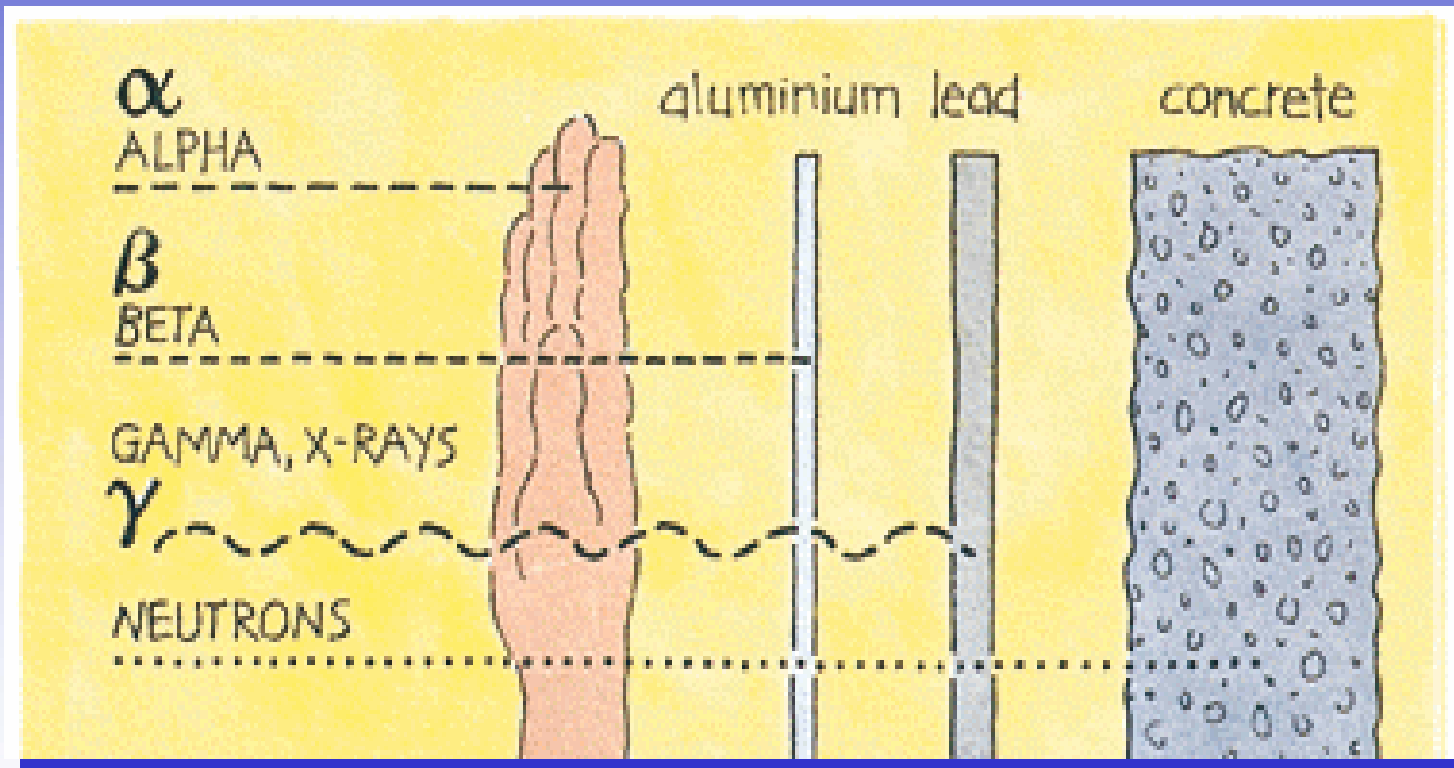
3 meters: 1.8 mR / hr

4 meters: 1.0 mR / hr





Time - Distance - Shielding

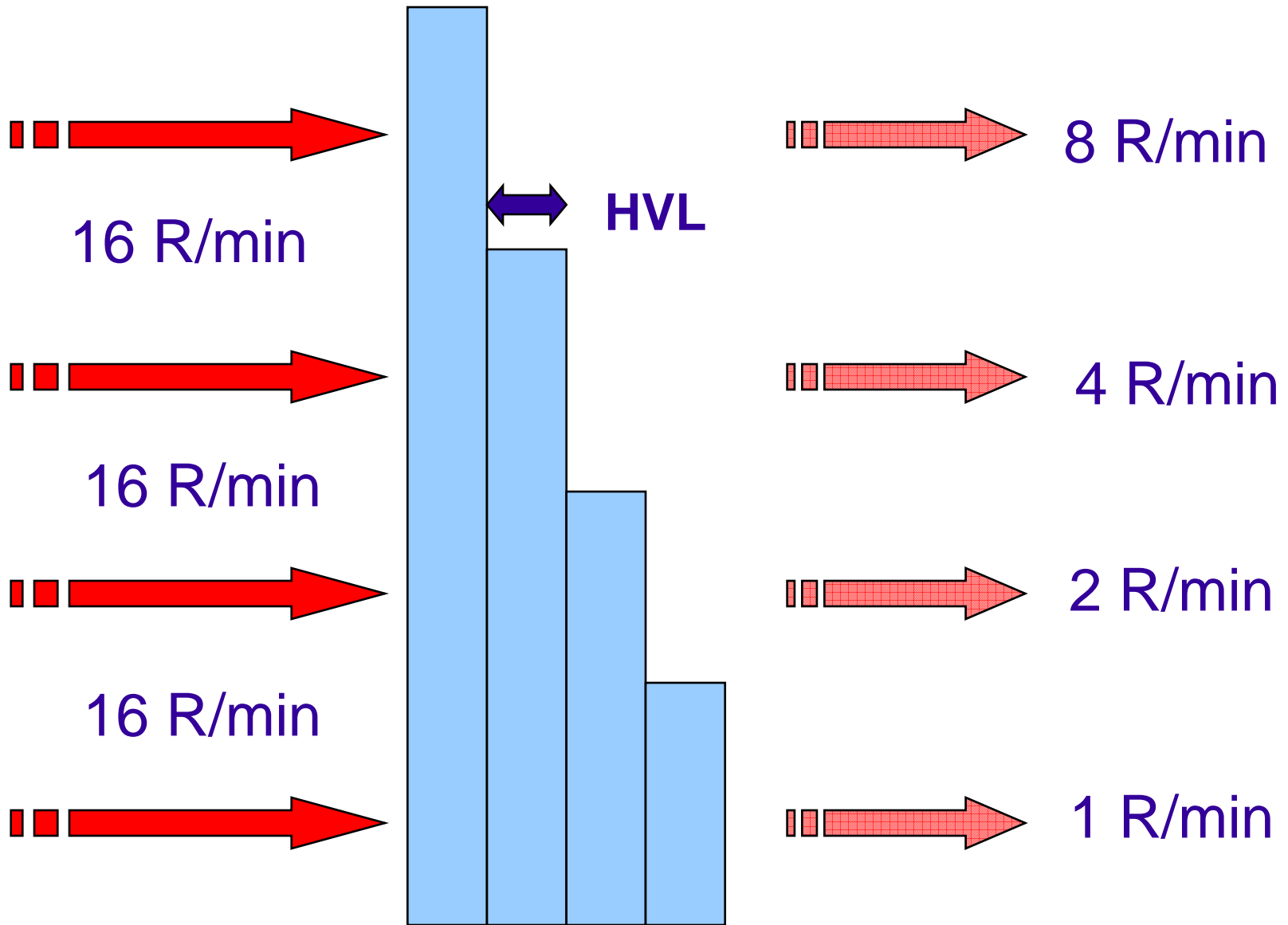


Soft betas from C-14 and tritium are stopped in glassware. P-32 beta is stopped by 3-5 mm Lucite. Heavy metals are required to stop gammas.



Half Value Layer (HVL)

- Is the thickness of a shielding material required to reduce the transmitted exposure rate (R) to one-half the incident exposure rate (R_0).
- HVL depends upon the material's atomic number and density, and upon the energy spectrum of the incident photons.





Attenuation of Photons by Shielding

$$R = R_0 (\exp (- 0.693 t / \text{HVL}))$$

R = Attenuated exposure rate

R₀ = Primary Exposure Rate

t = thickness of shielding (cm)

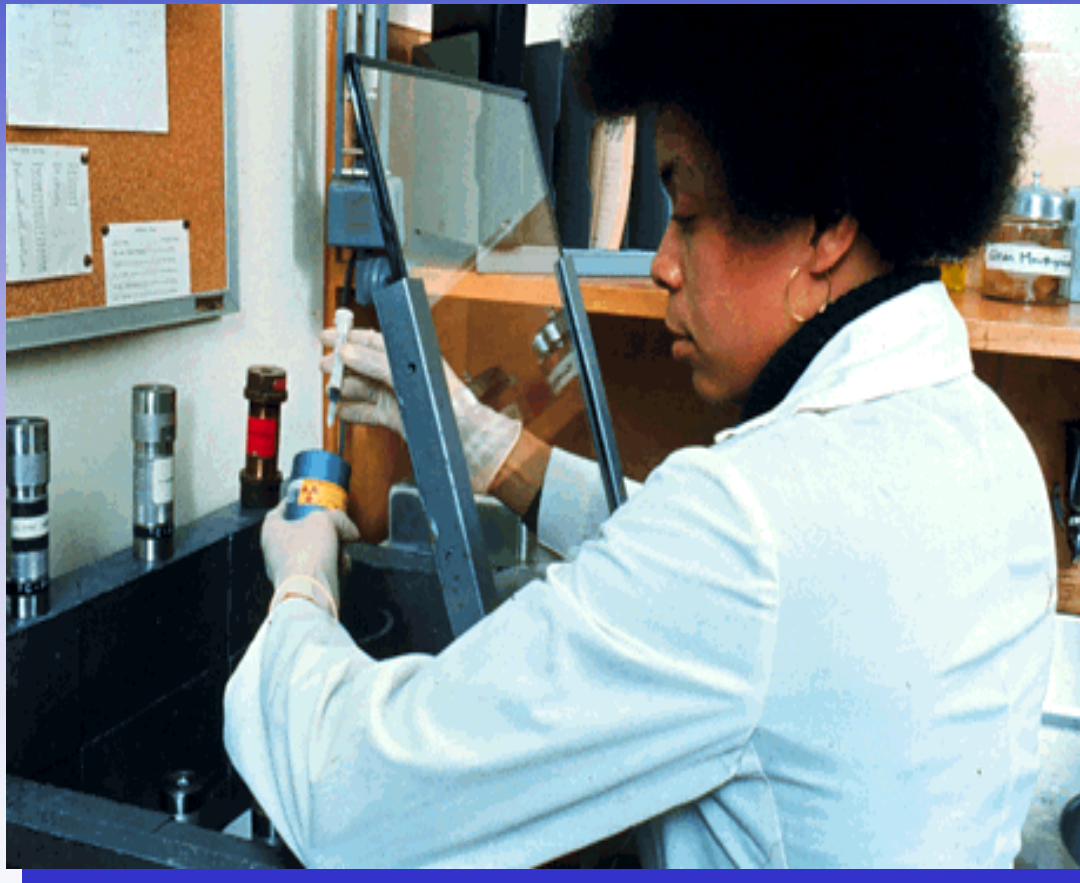
HVL = “Half Value Layer” (cm)



Half Value Layer (HVL)

Energy (kVp)	Lead (cm)	Concrete (cm)
50	0.005	0.432
70	0.015	0.838
100	0.024	1.524
125	0.027	2.032
150	0.029	2.235

Typical “Shadow” Shield



“Rule of Thumb: Shadow Shield provides maximum reduction of about 1 part in 400

PPE -- Lead Aprons



Lead aprons must contain shielding equivalent to 0.5 mm thickness of lead. The “wrap-around” type affords increased protection from scattered radiation. Light-weight, non-lead aprons are available.

PPE -- Collars and Glasses



Shielding collars and leaded glasses protect the thyroid gland and the lens of the eye from ionizing radiation.

PPE -- Shielding Gloves



Shielding gloves shall be worn if the hands are placed in the useful (primary) x-ray beam.



Controlling Contamination



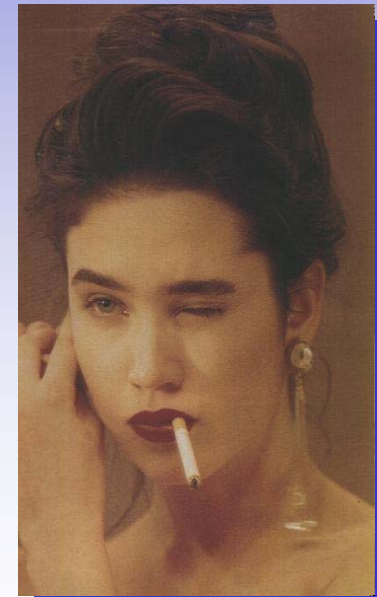
- **Cover work surfaces**
- **Wash hands frequently**



Controlling Contamination



- Don't Drink
- Don't Eat
- Don't Smoke
- No cosmetics





Controlling Contamination: *PPE*



- **Lab Coats**
- **Gloves**
- **Fume Hood**



Radiation Survey Instruments





Survey Meter Quality Assurance

- **Meters OFF when not in use**
- **Operation check with each use**
- **Regular battery and high-voltage checks**
- **Annual calibration**



End of Module IV

- **This concludes Module IV.**