

Radiation Protection

Radiation Protection Safeguards in Industrial Processes

- **All industrial processes pose safety hazards (mechanical, electrical, chemical, biological)**
- **Radiation Processing also poses safety hazards**
 - **Radiation exposure of workers**
 - **Electrical (high-voltage equipment, particularly with accelerators)**
 - **Mechanical (conveyor belts, devices to move and rearrange packages)**
 - **Biological (rarely, contamination levels generally low)**

Radiation Protection

The ALARA Principle

ALARA: As Low As Reasonably Achievable

- **Provide sufficient shielding to reduce dose to personnel to negligible levels**
- **Administrative procedures for safe operation of radiation equipment**
- **Fail-safe interlocks to prevent accidental exposure**

Radiation Protection

General Safety Rules

- **No entry into a controlled radiation area unless wearing a dosimeter, e.g., film badge**
- **Equipment should not be used if safety devices are not working**
- **Only one operator of the radiation equipment at any given time**

Radiation Protection

General Safety Rules (contd)

- **Operation of radiation equipment only by persons qualified to operate it**
- **All equipment malfunctions, even if minor or temporary, should be reported**
- **Every person has the responsibility to shut down radiation equipment if suspected that personnel are in danger**

Radiation Protection

Effects of Human Exposure

- <0.5 Gy - No visible short-term effects**
- 0.5 Gy - Increase in white cell count**
- 0.5-2 Gy - Increase in white cell count, nausea, fatigue**
- 2-4 Gy - Headache, nausea, fever, fatigue, chills, loss of appetite, loss of hair**
- 4-5 Gy - Can be lethal ($LD_{50} \sim 4.5$ Gy)**
- 6.5-8 Gy - Death in <22 days**
- 8-10 Gy - Immediate death**

Radiation Protection

Radiation Exposure of Humans Undesirable

- **Extremely important - control the dose received by personnel**
- **Shielding a controlling primary step in protection against such exposure**

Radiation Protection

ICRP Recommended Dose Limits^{1,2}

Application	Dose Limit	
	Occupational	Public
Effective dose	20 mSv per yr averaged over defined periods of 5 yrs	1 mSv in a yr
Annual equivalent dose		
in the lens of the eye	150 mSv	15 mSv
in the skin	500 mSv	50 mSv
in the hands and feet	500 mSv	-

¹ ICRP Publication 60 (1990)

² For e⁻ and γ, 1 Sv = 1 Gy

Radiation Protection

Use of Radiation Monitors

- **Personnel Monitors**
 - TLD or film**
 - Pocket ion chamber**
- **Area Monitors**
 - With audible alarms**
 - able to shut down radiation source**
- **Geiger-Müller counter**
 - For routine surveys to detect radiation**

(IAEA Technical Report No. 188)

LD₅₀ Values: Whole Body Exposure (X- or Gamma-rays)^a

Animal	LD₅₀ (kGy)
Dog	3.5
Guinea Pig	4.0
Human	2.5 to 4.5^b
Mouse	5.5
Monkey	6.0
Chicken	6.0
Frog	7.0
Rat	7.5
Rabbit	8.0
Tortoise	15.0
Goldfish	23.0

^a Casarett (1968)

^b The accepted value is 4.5 Gy

Conclusions

- **Radiation protection of workers at a radiation processing facility is extremely important**
- **The overall cost of radiation protection is a small part of the cost of radiation processing**
- **While most radiation processing facilities have a person in charge of radiation protection, everyone there should be well aware of the need and the details of radiation protection measures**