# 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 ($LD_{50}$ ~ 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 $\gamma$, 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)

# $LD_{50}$ Values: Whole Body Exposure (X- or Gamma-rays)[a]

| Animal | $LD_{50}$ (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