PRINCIPLES AND METHODS OF RADIATION PROTECTION
Lesson Outcomes

At the end of the lesson, student should be able to:

• Define what is radiation protection (RP)
• Describe basic principles of RP
• Explain methods of RP
Basic principles of radiation protection
Basic principles of radiation protection

• Justification of practice
• Optimization of protection
• Individual dose limits
The justification of a practice. No practice involving exposure to radiation should be adopted unless it produces sufficient benefit to the exposed individual or to society to offset the radiation detriment it causes.

The optimization of protection. All exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account.

Individual dose limits. The dose equivalent to individuals shall not exceed the recommended dose limits.
Justification of Practice

• In proposed and continuing practices, the justification of practice must be such that the work uses radiation because it gives benefit (or gain) to the exposed individuals or to society that exceeds radiological risk.

• Justification in intervention provides more benefit in comparison to if there were no intervention.
Optimization of Protection and Safety

• Based on the principles of ALARA (As Low As Reasonably Achievable).

• For any given radiation source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures should be kept to as low as reasonably achievable, taking economic and social factors into considerations.
Dose Limit

• Dose limit is used to apply controls on each individual’s accumulation of dose.

• Dose limits are not:
  – a line of demarcation between “safe” and “dangerous”
  – the sole measure of the stringency of a system of protection.

• Dose limits do not include medical exposures and natural background radiation.
The **millisievert** and **milligray** as measures of radiation dose and exposure

- In the **SI system**, a **millisievert (mSv)** is defined as "*the average accumulated background radiation dose to an individual for 1 year, exclusive of radon, in the United States.*"
- **1 mSv** is the dose produced by exposure to **1 milligray (mG)** of radiation.
• In historical system, exposure to 1 roentgen (R) of X-rays results in absorption of 1 rad [radiation-absorbed dose], which had the effect of 1 rem [roentgen-equivalent (in) man].

• The unit equivalences between the systems are given in the following table:

<table>
<thead>
<tr>
<th>SI units</th>
<th>Historical dosimetry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Gray</td>
<td>100 R</td>
</tr>
<tr>
<td>1 Sievert</td>
<td>100 rem = 100 rad</td>
</tr>
<tr>
<td>10 mGy</td>
<td>1 Roentgen</td>
</tr>
<tr>
<td>10 mSv</td>
<td>1 rem = 1 rad</td>
</tr>
</tbody>
</table>
Annual Dose Limits (ADL)

• There are different categories of dose limits for:

1. radiation workers;
2. members of the public;
3. trainees of radiation;
4. planned special exposures; and
5. female pregnant workers.
## ADL for Occupational Exposure

<table>
<thead>
<tr>
<th>Application</th>
<th>ADL (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual dose limit for the whole body exposure of worker</td>
<td>20</td>
</tr>
<tr>
<td>Female pregnant worker: dose to the foetus accumulated over the period of time between confirmation of pregnancy and the date of birth</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Partial body exposure of a worker:</td>
<td></td>
</tr>
<tr>
<td>i. Limit for the effective dose-equivalent</td>
<td>50</td>
</tr>
<tr>
<td>ii. Limit on average dose in each organ or tissue</td>
<td>500</td>
</tr>
<tr>
<td>iii. Limit for lens of the eyes</td>
<td>150</td>
</tr>
<tr>
<td>iv. Limit on equivalent dose for the hands and feet</td>
<td>500</td>
</tr>
</tbody>
</table>
The **ALARA** philosophy

As low as reasonably achievable
The **ALARA** philosophy is based on the assumption that exposure to radiation poses a risk. The cautious assumption that a proportional relationship exist between dose and effect for all doses (non-threshold concept) is the basis for ALARA. Since, in a statistical sense, any radiation exposure carries a risk, however small, exposures should be kept **as low as reasonably achievable** - ALARA.

The goal of radiation safety is to keep radiation exposures--both internal and external--**As Low As Reasonably Achievable** (ALARA).
Primary methods of radiation protection

Reduction of radiation exposure is the primary goal for a radiation protection programme.
Basic methods of protection against exposure to ionizing radiation

Three basic factors

- time
- distance
- shielding
The amount of exposure an individual accumulates is directly proportional to the time of exposure. The longer the time spent exposed to radiation the greater the potential for absorbing a dose of radiation. It is therefore important to minimize the time near radioactive sources. Never sit, chat, read or hold telephone conversations in the presence of radioactive materials.
Exposure rate = 10 mGy/h

Time × Total dose =

1 hour = 10 mGy

2 hours = 20 mGy
Distance

The same way that heat from a fire is less powerful the further away you are, the intensity of radiation decreases the further you are from the source.
DISTANCE

Reduction of radiation dose inversely proportional to the square of the distance or it follows the inverse square law equation.

\[
\frac{I_1}{I_2} = \frac{d_1^2}{d_2^2}
\]

where \( I_1 \) and \( I_2 \) are radiation intensities at distances \( d_1 \) and \( d_2 \) respectively.
Inverse square law

The relationship between distance and exposure follows the inverse square law - the intensity of the radiation exposure decreases in proportion to the inverse of the distance squared.

\[ \text{Intensity} \propto \frac{1}{d^2} \]

\[ \text{150 mSv/h} \quad \text{at} \quad d=50\text{cm} \quad \Rightarrow \quad 0.06 \text{ mSv/h} \]
Shielding photons

X and gamma rays are diminished in intensity by any absorber but not completely stopped. Materials having a high atomic number can absorb more photons than lighter elements. For X and gamma emitters, shielding is usually lead. The thickness will depend on the half value layer of the photon in the chosen material.
Half value layer (HVL)

The ability of shielding material to attenuate radiation is generally given as half value layer. This is the thickness of the material which will reduce the amount of radiation by 50%.