RADIATION
SAFETY STANDARDS
&
DOSE LIMITS

Chapter # 8

Dose limits are needed …

To protect from harmful effects:

1. To keep dose below the threshold level for deterministic effects (non-stochastic), and

2. To keep the risk of stochastic effects (random) at an acceptable level.

Radiation Safety Standards

- Standards start with recommendations by the International Commission on Radiological Protection (ICRP)
- These recommendations that include, dose limits, are incorporated into the national regulations

Regulatory Body of Radiological Control

- KACST is the governmental organization that puts the national regulations (based on the ICRP recommendations and the IAEA Basic Safety Standards (SS#115)) for :
  - use of radiation sources and radiation producing machines,
  - the dose limits

Basis for the Radiation Protection Standard

- Justification,
- Optimization, and
- Dose Limitation

Basis for the Radiation Protection Standard

Justification

- A particular use of radiation cannot be justified unless …
  - there is a net benefit arising from that use, and
  - that other alternatives cannot be used

Basis for the Radiation Protection Standard

Optimization

- All exposures are to be kept As Low As Reasonably Achievable, (ALARA), where …
  - economic and
  - social factors being taken into account.

Realization of ALARA

- Have management commitment and policy for applying of ALARA principle by:
  - Educating and training
  - Design considerations
  - Operational radiation protection program

Basis for the Radiation Protection Standard

Dose Limitations

- The dose received by individual resulting from all practices should not exceed the recommended limits

Dose limits are applied …

1. Radiation workers,
   - Men, women, and young workers

2. Members of the public.

Dose Limitations

- Types of Limits
  - **Primary limit**
    - maximum value for the Equivalent dose or the Effective Dose
  - **Secondary limit**
    - used when the primary limit is not applicable
  - **Derived limit**
    - related to the primary mathematically
  - *Acceptable limit*
    - *put by special regulatory authority, it is < than primary*
  - *Working limit*
    - *Put by the management*

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Annual Dose Limits (primary limit)

Occupational limit

- Occupational persons:
  - Adults (men and women)
  - Adults aged 16-18 years
  - Adults under 16 years old
  - Pregnant woman

Annual Dose Limits

(primary limit)

Occupational (adults, men and women not pregnant)

- **Effective Dose** 20 mSv

  (averaged over 5 years, max in 1 year:50 mSv)

- **Equivalent Dose in:**
  - The lens of the eye 150 mSv
  - The skin 500 mSv
  - The hands & feet 500 mSv

Annual Dose Limits (primary limit)

Occupational limit (2)

- Exposure of adults of 16 - 18 years old should not exceed:
  - **Effective Dose** 6 mSv/y
  - **Equivalent Dose in:**
    - The lens of the eye 50 mSv/y
    - The skin 150 mSv/y
    - The hands & feet 150 mSv/y

Annual Dose Limits (primary limit)

Occupational limit (3)

- Exposure of individual under 16 years old
  - **No person under the age of 16 years should be subjected to occupational exposure**

Annual Dose Limits (primary limit)

Occupational limit (4)

- Exposure of pregnant woman
  - **The embryo/fetus is sensitive to radiation**
  - **Exposure of a pregnant woman is limited to**
    - **2 mSv of equivalent dose to the abdomen, and**
    - **an intake of 1/20 of the annual ALI, for the term of pregnancy**

$$H/2 + I_l/(1/20\ ALI) \leq 1$$

Annual Dose Limits

	Limit (mSv/y)	
	Occupational	Public
• **Effective Dose**	20 ave over 5 y, 50 mSv max in a single year	1
• **Equivalent Dose in**		
The lens of the eye	150	15
The skin	500	50
The hands & feet	500	----

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Secondary Limits

- If the primary limit is not applicable
- Mostly used for internal exposure
- Limitation achieved by the setting of the Annual Limit of Intake (ALI) by ingestion or inhalation

Annual Limit of Intake (ALI)

- ALI is the activity of a radionuclide that, if taken into the body in a year will result in a committed effective dose to a reference person equal to the annual dose limit, i.e., 20 mSv

Annual Limit of Intake (ALI) (4)

- ALI for ingestion or inhalation is calculated for radionuclide j by

$$ALI = \frac{20 \times 10^{-3}\ \mathrm{Sv}}{\mathrm{h(g)}_{\mathrm{j}}}$$

- Unit of ALI: Bq

Derived Limits (DL)

- Limits related to the primary H_T or ALI mathematically
- Derived Air Concentration (DAC)

DAC

- DAC limits are derived by modeling the bodily intake from the air by breathing 1.25 m^3 per hr of air 50 weeks at 40 hours per week.

$$DAC = \frac{ALI}{2.5 \times 10^3} Bq / m^3$$

Non-uniform irradiation (Example)

- Calculate the allowable equivalent dose to the thyroid of a worker for a year resulting from non-uniform irradiation of the whole body, the lung and the thyroid.

  During the year he received equivalent doses of 10 mSv to the whole body and 50 mSv to the lung.

Solution

- $\sum_T w_T H_T \leq 20$ mSv
  $1 \times 10 + 0.12 \times 50 + 0.05\ H_T(th) \leq 20$ mSv
  $16\ \text{mSv} + 0.05\ H(th) \leq 20$ mSv
  $H_T(th) \leq 80$ mSv

- Thus, the worker is permitted to receive up to 80 mSv equivalent dose to the thyroid during that year.

Example

The measured dose rates in an accelerator hall are the following:

100 μSv/h	from fast neutrons
20 μSv/h	from slow neurons
40 μSv/h	from gamma rays

What is the max. time per day that a worker can work in the hall?

Solution

Total dose rate $= 100 + 20 + 40$

$= 160\ \mu Sv/h$

Daily limit = 20 (mSv/y) x 50 (w/y) x 5 (d/w)

= 0.08 (mSv/d)

$$\text{The max. time/day} = \frac{0.08\ mSv/d}{160\ \mu Sv/h} = 0.5\ h/d$$

Example

- How many hours could a worker spend in a week in a radwaste storage where the average effective dose rate is 0.1 mSv/h?

Solution

$$\text{Dose limit in a week} = \frac{20\ \text{mSv/y}}{50\ \text{w/y}} = 0.4\ \text{mSv/week}$$

$$\text{Time} = \frac{0.4\ \text{mSv/w}}{0.1\ \text{mSv/h}} = 4\ \text{h/w}$$