Presentation Part I
RADIOTHERAPY
METHODOLOGY FOR DOSE ESTIMATES IN NORMAL OPERATION.

*Internacional Atomic Energy Agency*
OBJECTIVE

- Methodology for dose estimation in normal operating teletherapy conditions.
- Example of dose estimation in normal operating teletherapy conditions.
To estimate doses during normal operating conditions it is necessary to identify the people potentially exposed and the exposure conditions during the daily routines.

It is required to do estimations for:

1. Exposed workers.
2. Members of the public.
### Exposed Workers in the Practice of Teletherapy

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# Exposed Workers in the Practice of Cobalt Therapy

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Co-60 unit operator.

The estimation of the dose during the unit operation, from the control panel, depends on the control panel location:

1. Control panel located on a Primary barrier.
2. Control panel located on a Secondary barrier.
The instantaneous dose rate (IDR) at the primary barrier can be estimated by the equation:

\[
IDR = \frac{DR_0 \cdot B}{d^2}
\]

DR\(_0\) : dose rate at the isocentre of the equipment.
B: barrier transmission factor. (*)
d: distance at the calculus point.

\[
(*) \quad B = 10^{\left\{1 + \left[\frac{S - TVL_1}{TVL_\infty}\right]\right\}}
\]

S: thickness of the barrier.
TVL: Tenth Value Layers.

EXAMPLE OF DOSE ESTIMATIONS
Co-60 UNIT OPERATOR

1. Control panel located on a Primary barrier

The instantaneous dose rate (IDR) at the primary barrier can be estimated by the equation:
The average dose rate that the operator receives in a week can be estimated from the instantaneous doses rate (IDR):

\[ R_w = IDR \times \frac{W \ U \ T}{DR_0} \]

DR\(_0\): Dose rate at the isocenter of the equipment.
W: Weekly work load,
U: Use factor
T: Occupation factor.

The annual dose received by a control panel operator is:

\[ D_1 = R_w \times N_w \]

N\(_w\): Number of working weeks in a year.
The instantaneous dose rate (IDR) at the secondary barrier can be estimated by the equations:

\[ IDR_p = \frac{a \cdot DR_0 \cdot B_p}{d_{sca}^2 \cdot d_{sec}^2} \cdot \frac{F}{400} \]

\[ IDR_f = \frac{10^{-3} DR_0 \cdot B_f}{d_f^2} \]

- \( B_p \) and \( B_f \): transmission factors of disperse and leak radiation
- \( DR_0 \): dose rate at the isocenter of the unit
- \( d_{sca} \): distance between the source of radiation and the patient, in meters
- \( d_{sec} \): distance from the patient to the interest point, in meters
- \( d_f \): distance from the head of the unit to the interest point, in meters
- \( \alpha \): dispersion fraction defined at the distance \( d_{sca} \). Look at the Bibliography.  \( (\alpha(30°) = 3.18E-03 \text{ (15MV)} = 6.00E-03 \text{ (Co-60 1.25 MeV)}) \)
- \( F \): Radiation field area affecting the patient, in cm². It is assumed a typical treatment radiation field size of 15x15 cm.
2. Control panel located on a Secondary barrier

The instantaneous total dose rate is:

$$IDR_T = IDR_p + IDR_f$$

The average dose rate that the operator receives in a week can be estimated from the instantaneous total doses rate ($IDR_T$):

$$R_w = IDR \times \frac{W \times U \times T}{DR_0}$$

$DR_0$: Dose rate at the isocenter of the equipment
$W$: Weekly work load
$U$: Use factor (for the Secondary barrier, use factor =1)
$T$: occupation factor.

The annual dose received by a control panel operator is:

$$D_1 = R_w \times N_w$$

$N_w$: Number of worked weeks in a year.
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Considerations for dose estimation

1. According to the standard IEC 60601-2-1 it is assumed that the dose rate at 1 m from the head of the unit is 0.02 mGy/h.

2. $N_0$ patients a day are treated, assuming that each work shift has 2 technicians and each technician positions half of the patients.

3. Each patient receives an average of 3 radiation fields in each treatment session.

4. In each positioning field the technician spends 2 minutes.

5. Technicians work 5 days a week, 50 weeks a year.


\[ D_2: \text{Annual dose due to the positioning of the patients} \]

\[ D_2 = \frac{N_o}{2} \text{pat/days} \times 3 \text{ pos/pat} \times 0.0333 \text{ h/pos} \times 0.02 \text{ mSv/h} \times 50 \text{ weeks/year} \times 5 \text{ days/week} (\text{mSv/year}) \]
Annual total dose (\(D_{\text{ta}}\)) that the operator receives in normal operating conditions.

\[
D_{\text{ta}} = D_1 + D_2
\]

**Conclusion:** \(D_{\text{ta}}\) must be less than the dose constrain (\(P\))
## Exposed Workers in the Practice of LINAC Therapy

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Annual total dose ($D_{ta}$) that the operator receives in normal operating conditions.

\[ D_1 + D_2 = 0 \]

\[ D_{ta} = D_1 \]

**Conclusion:** $D_{ta}$ must be less than the dose constrain ($P$)
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<th>Members of the Public</th>
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<td>Patient’s escort</td>
<td>Waiting during treatment</td>
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<td>Hospital workers and other patients</td>
<td>Offices, bathrooms, halls where the hospital workers are present.</td>
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To estimate the doses received by the members of the public we use the same equations that are used to estimate the control panel operator doses. Distances, use and occupation factors should be realistic.

**Primary barrier:**

\[
IDR = \frac{DR_0 \cdot B}{d^2}
\]

**Secondary barrier:**

\[
IDR_p = \frac{a \cdot DR_0 \cdot B_p \cdot F}{d_{sca}^2 \cdot d_{sec}^2 \cdot 400}
\]

\[
IDR_f = \frac{10^{-3} \cdot DR_0 \cdot B_f}{d_f^2}
\]