



**Presentation**  
**RADIOTHERAPY**  
**METHODOLOGY FOR DOSE ESTIMATES IN**  
**ACCIDENT CONDITIONS.**

**International Atomic Energy Agency.**



## **OBJECTIVE.**

- **Example of dose estimation for a potential accident in Teletherapy practice.**
- **Example of dose estimation for a potential accident in Brachytherapy practice.**

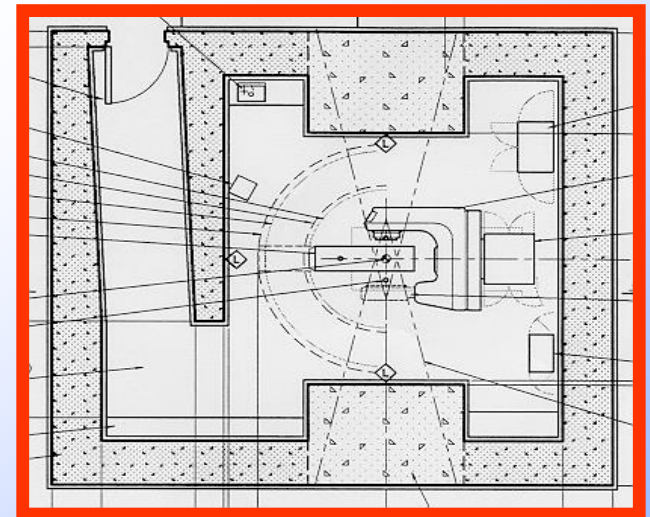


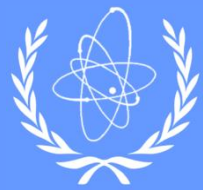
# INTRODUCTION

The estimations of doses in conditions of accident start from identifying the main scenarios, that because of their probability and the consequences, could happen in extreme conditions. It is recommended to analyze accident scenarios previously occurred.

**Dose estimates are required for people who may be affected:**

- 1. Exposed Workers.**
- 2. Members of the Public.**

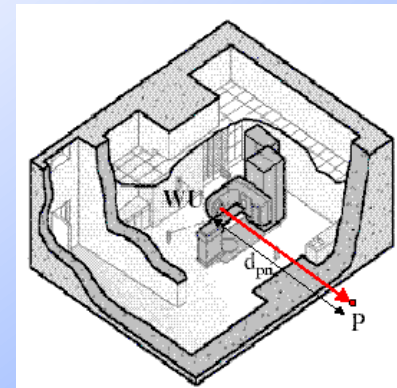




# SCENARIOS. TELETHERAPY PRACTICE

## Most relevant scenarios in the teletherapy practice

1. Unnoticed blockage of the source while a patient is treated: *Consequences for patients and workers.*
2. Loss of a source during storage or transportation: *Consequences for the public.*
3. Wrong calibration of the teletherapy unit: *Consequences for patients.*
4. Wrong elaboration of a patient's treatment plan: *Consequences for patients.*
5. Inadvertent entry of a worker or a member of the public into the treatment room: *Consequences for the public and workers.*
6. Inadvertent permanence of a worker or a member of the public inside de Bunker while a patient is treated: *Consequences for public and workers.*

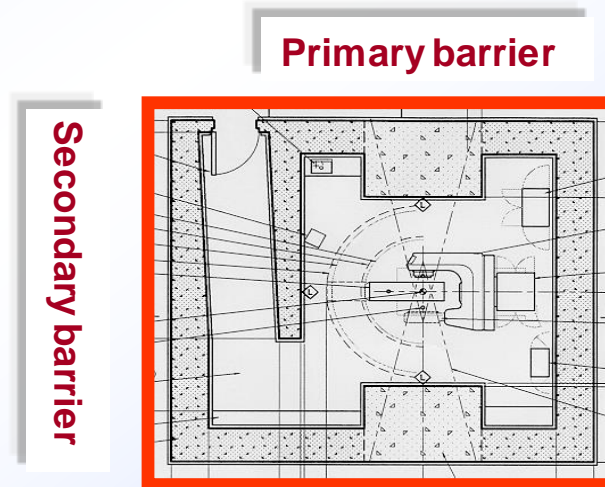


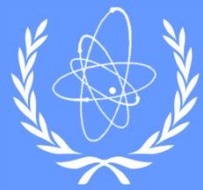


# EXPOSURE SCENARIOS

There are 3 different ways of exposure of a person once an event happens:

1. The person is exposed to the primary radiation beam.
2. The person only receives secondary radiation (leakage radiation from the head of the unit that is scatter to the patient).
3. The person holds the teletherapy source in his hands (Just in cases where the teletherapy source remains in public premises).

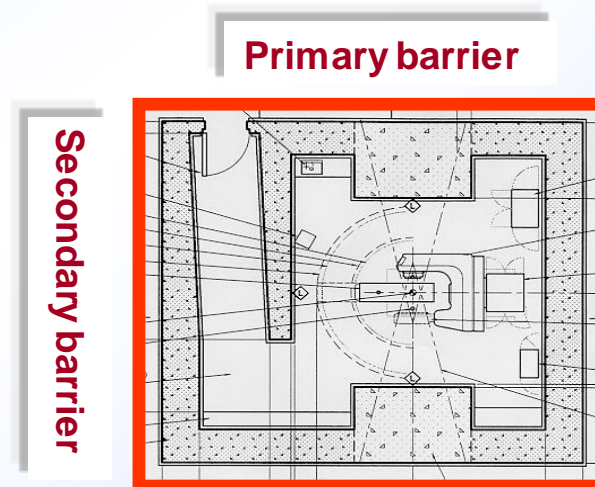


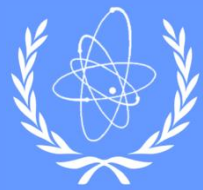


# EXAMPLE OF DOSE ESTIMATIONS Co-60 UNIT. EXPOSED WORKERS

**Example 1: Unnoticed blockage of the source while a patient is treated: *Consequences for patients and workers.***

1. The person is exposed to the primary radiation beam.
2. The person only receives secondary radiation (leakage radiation from the head of the unit that is scatter to the patient).





# EXAMPLE OF DOSE ESTIMATIONS Co-60 UNIT. EXPOSED WORKERS

## 1. The person is exposed to the primary radiation beam.

The dose rate that a person located at a «d» distance from the equipment source primary beam, can be estimated by the equation:

$$D_{Hp} = D_{TTo} (d_o^2 / d^2)$$

$D_{Hp}$ : dose rate received from the primary beam.

$D_{TTo}$ : dose rate at the isocentre of the unit.

$d_o$ : distance from the source to the isocentre of the unit .

$d$ : distance from the source to the exposed person.

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# EXAMPLE OF DOSE ESTIMATIONS Co-60 UNIT. EXPOSED WORKERS

## 2. The person is exposed to secondary radiation.

The dose received by a person located at a certain distance from the isocenter of the unit, out of the primary beam, is the sum of the received dose due to the scatter radiation in the patient and the radiation leakage from the head of the unit.

$$D_T = D_f + D_p$$

$D_T$  Total dose.

$D_f$  Dose due to the leakage radiation.

$D_p$  Dose due to the scatter radiation.





# EXAMPLE OF DOSE ESTIMATIONS Co-60 UNIT. EXPOSED WORKERS

## 2. The person is exposed to secondary radiation.

$$D_T = D_f + D_p$$

Both dose contributions can be estimated by the following equations:

$$D_p = \frac{\alpha D (F/400)}{d_{sca}^2 d_{sec}^2} \qquad D_f = \frac{10^{-3} D}{d_f^2}$$

**D<sub>p</sub>** – Dose due to the scatter radiation.

**D<sub>f</sub>** – Dose due to the leakage radiation.

**D** – Patient absorbed dose,

**d<sub>sca</sub>** – Distance from the radiation source to the patient, in meters,

**d<sub>sec</sub>** – Distance from the point of interest to the patient, in meters,

**d<sub>f</sub>** – Distance from the head of the unit to the interest point, in meters,

**α** – Scatter fraction defined at the distance d<sub>sca</sub>. (α(30°)= 3,18E-03 (15MV)= 6,00E-03 (Co-60 1.25 MeV)).

**F** - Radiation field area affecting the patient, in cm<sup>2</sup>. It is assumed a typical treatment radiation field size of 15x15 cm



# EXAMPLE OF DOSE ESTIMATIONS

## Co-60 UNIT. MEMBERS OF THE PUBLIC

### Potential doses to patients.

Potential accidental doses might vary significantly depending on the particularly initiating event. Three major accidental groups can be identified:



- Accidents that cause major dose deviations with respect the prescribed doses (more than 25%) and many patients are affected. This group of accidents can be classified as **systematic** accidents.
- Accidents that cause major dose deviations with respect the prescribed doses (more than 25%) but only one patient is affected. It might cause death and incapacity damage just to the affected patient. This group of accidents can be classified as **programmatic** accidents.
- Accidents that cause moderate dose deviations with respect the prescribed doses (up to 25%). Patient's life is not at risk. Usually, patient is affected during the treatment session. This group of accidents can be classified as **episodic** accidents.

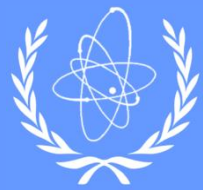


# SCENARIOS. BRACHYTHERAPY PRACTICE

## Most relevant scenarios in the brachytherapy practice

1. Unnoticed blockage of the source while a patient is treated: *Consequences for patients and workers.*
2. Unplugging the brachytherapy HDR push cable during patient treatment: *Consequences for patients and workers.*
3. Loss of a source during storage or transportation: *Consequences for the public.*
4. Wrong calibration of the brachytherapy unit: *Consequences for patients.*
5. Wrong elaboration of a patient's treatment plan: *Consequences for patients.*
6. Inadvertent entry of a worker or a member of the public into the treatment room: *Consequences for the public and workers.*
7. Inadvertent permanence of a worker or a member of the public inside de Bunker while a patient is treated: *Consequences for public and workers.*





# EXAMPLE OF DOSE ESTIMATIONS BRACHYTHERAPY. EXPOSED WORKERS

**There are 2 different ways of exposure of a person once an event happens:**

1. The person is exposed to the primary radiation beam from the brachytherapy source. (In brachytherapy, sources emit radiation in all directions, “4 $\pi$ ”)
2. The person holds the brachytherapy source in his hands.





# EXAMPLE OF DOSE ESTIMATIONS BRACHYTHERAPY. EXPOSED WORKERS

## 1. A person is exposed to primary radiation.

The radiation dose rate that a person receives, located at a «**d**» distance from the source, can be estimated by the equation:

$$\dot{H}_{ir} = \frac{\Gamma \cdot A}{d^2}$$

Where:

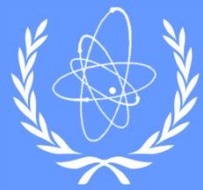
**Γ** is the gamma constant for the radioisotope used (**Γ** for I-192 is 0.135 mSv m<sup>2</sup>/ GBq h).

**A** is the source activity.

**d** is the distance from the irradiation point to the irradiated person.

$$\mathbf{D = H * t_0}$$

where **t<sub>0</sub>** is the time of exposure.



# EXAMPLE OF DOSE ESTIMATIONS BRACHYTHERAPY. EXPOSED WORKERS

## 2. The person holds the brachytherapy source in his hands.

The received dose for holding the source during a determinate period of time can be estimated by the following equation:

$$D_c = F_c * T_c * A$$

Where:

**F<sub>c</sub>** is the conversion factor of the absorbed dose rate applied to the soft tissue, in Gy/Bq\*s. ( Table #15 EPR-D-VALUES 2006) ( for I-192 F<sub>c</sub>= 8.5 e<sup>-15</sup> Gy/Bq\*s)

**T<sub>c</sub>** is the time that a person holds the source in his hands.

**A** Initial source activity (assuming conservative considerations)

