Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

The purpose of radiation shielding is to limit radiation exposures to members of the public and employees to an acceptable level (1).

Three important parameters that influence external radiation exposure are: **time, distance, and shielding (6).**

Report No. 151 of the National Council on Radiation Protection and Measurements (NCRP) - are described recommendations and technical information for the shielding design and evaluation in modern radiotherapy facilities, using megavoltage x-ray and gamma-ray (1).

Occupational exposure is defined as all exposures of workers incurred in the course of their work (6).

Licensees as well as employers are responsible for occupational health and safety exposure (6).

Student is able to ...

... demonstrate the knowledge of radiation safety requirements of radiotherapy facilities.

... demonstrate the knowledge of treatment room design.

... demonstrate the principles of controlled and uncontrolled areas.

Freepik - Freepik.com

The purpose of radiation shielding is to limit radiation exposures to members of the public and employees to an acceptable level (1).

Three important parameters that influence external radiation exposure are: **time, distance, and shielding (6).**

Report No. 151 of the National Council on Radiation Protection and Measurements (NCRP) - are described recommendations and technical information for the shielding design and evaluation in modern radiotherapy facilities, using megavoltage x-ray and gamma-ray (1).

Occupational exposure is defined as all exposures of workers incurred in the course of their work (6).

Licensees as well as employers are responsible for occupational health and safety exposure (6).

Student is able to ...

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

The design of each radiotherapy bunker is unique due to the particular department (2).

In radiotherapy for staff working only with accelerators a monthly investigation level of 0.2 mSv effective dose (6).

Effective dose is a mathematical construct, concept, or surrogate of risk, used in radiation protection as the basis for calculating annual radiation limits to workers and members of the public from exposure to radiation and intakes of radionuclides (8).

Paragraph I.16 of the Basic Safety Standards (BSS) states that:
"A female worker should, on becoming aware that she is pregnant, notify the employer in order that her working conditions may be modified if necessary." (6).

Paragraph I.17 of the BSS states that:
"The notification of pregnancy shall not be considered a reason to exclude a female worker from work; however, the employer of a female worker who has notified pregnancy shall adapt the working conditions in respect to occupational exposure so as to ensure that the embryo or foetus is afforded the same broad level of protection as required for members of the public." (6).

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

Lead:

+ High physical density – small space requirements.
+ High atomic number – good shielding for low energy X Rays.

– Relatively expensive.
– Difficult to work with (3).

05.02.14 at Tartu University Hospital bunker construction

Iron/steel:

+ Relatively high physical density - space requirements acceptable.
+ Self supporting structure - easy to mount.

– Relatively expensive (3).
– Steel has no hydrogen and is quite transparent to neutrons in large area shields (1).

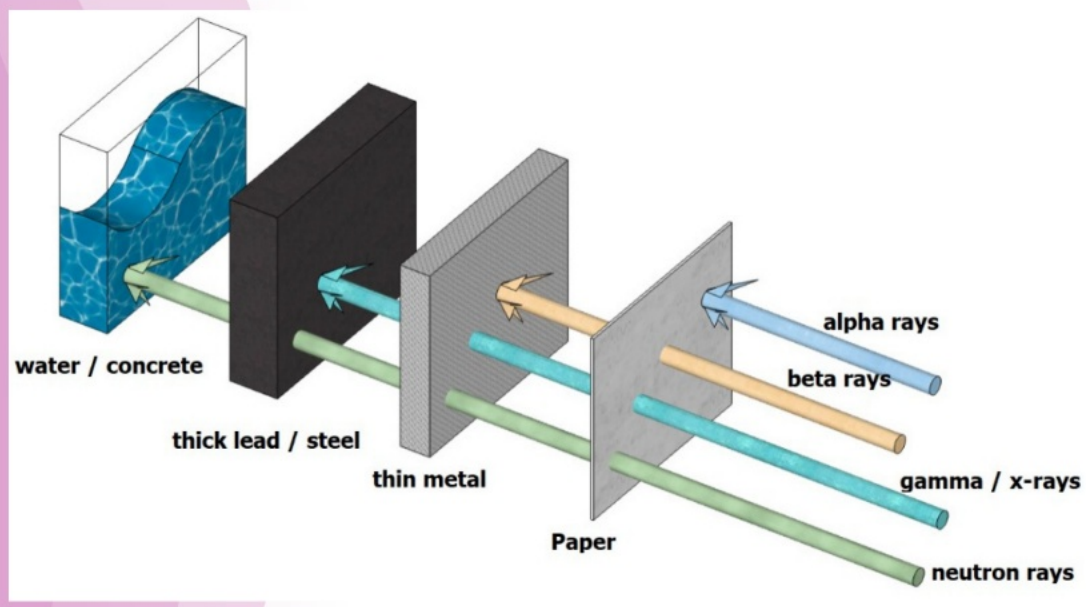
Continue...

Concrete:

+ Cheap (when poured at the time of building construction).
+ Self supporting (easy to use).

– Relatively thick barriers required for MV radiation.
– Variations in density may occur (difficult to monitor and control) (3).

https://www.dailyliberal.com.au/story/6919060/why-an-almost-complete-concrete-structure-offers-hope-to-the-region/



Type of radiations, penetrations and their properties (9).

Lead:

+ High physical density – small space requirements.
+ High atomic number – good shielding for low energy X Rays.

– Relatively expensive.
– Difficult to work with (3).

05.02.14 at Tartu University Hospital bunker construction

Iron/steel:

+ Relatively high physical density - space requirements acceptable.
+ Self supporting structure - easy to mount.

– Relatively expensive (3).
– Steel has no hydrogen and is quite transparent to neutrons in large area shields (1).

Continue...

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

The purpose of a bunker is to reduce external dose rates to below the respective design dose constraints.

An average life span ~30 years, each linac is only in use for ~10 years.

Bunker size has to be large enough to allow full extension of the couch in any direction, with room for an operator to walk around it.

The desirable size depends upon the type of treatments (eg. TBI procedure will require a larger treatment distance to one wall) (2).

MAZE

DOORS AND INTERLOCKS

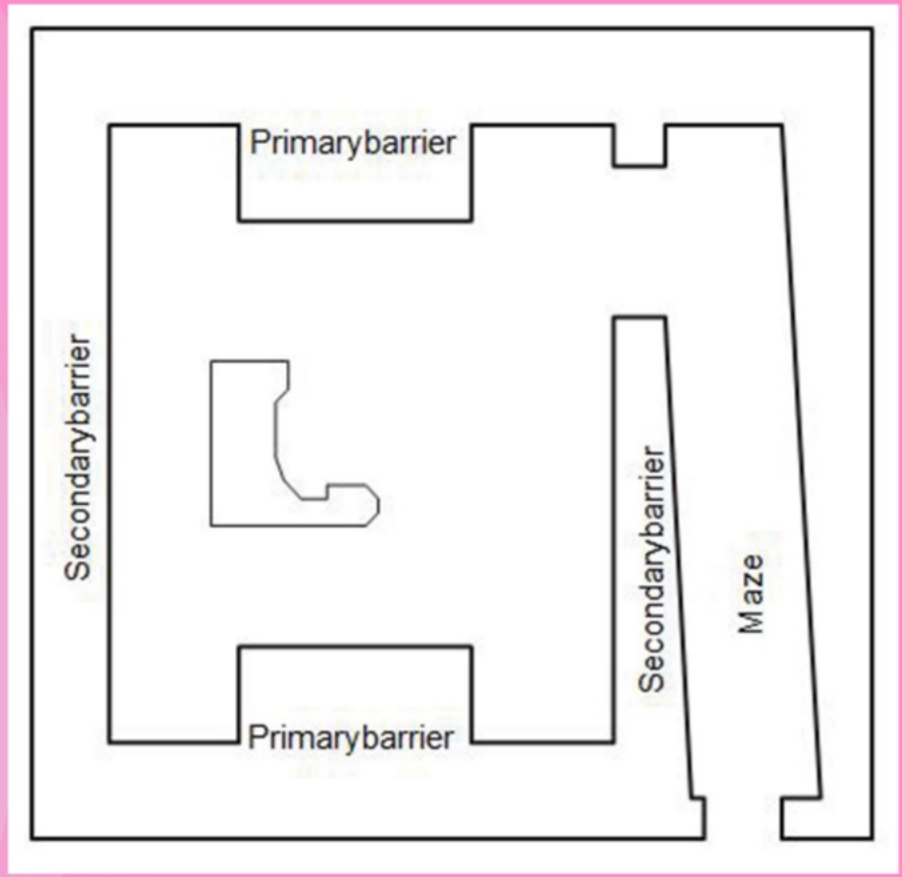
11.10.19 Tartu University Hospital C bunker

... is a term of a restricted access passageway leading to the room, in order to reduce the radiation dose near the entrance.

... ensures that photon radiation can only exit the room after scattering has attenuated it.

… reduces the need for a heavy shielding door.

If the length of the maze is sufficient, or if there are enough bends, there may be no need for a heavy lead door at the maze entrance (2).



https://medicalphysics.imedpub.com/the-structural-shielding-of-the-new-radiotherapy-bunker-at-the-general-hospital-of-yaounde-in-cameroon-an-enhancement-of-radiation.pdf

The purpose of a bunker is to reduce external dose rates to below the respective design dose constraints.

An average life span ~30 years, each linac is only in use for ~10 years.

Bunker size has to be large enough to allow full extension of the couch in any direction, with room for an operator to walk around it.

The desirable size depends upon the type of treatments (eg. TBI procedure will require a larger treatment distance to one wall) (2).

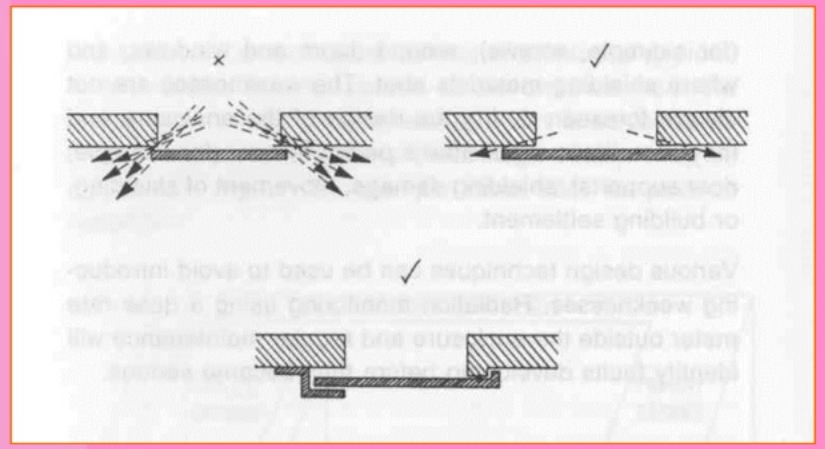
MAZE

DOORS AND INTERLOCKS

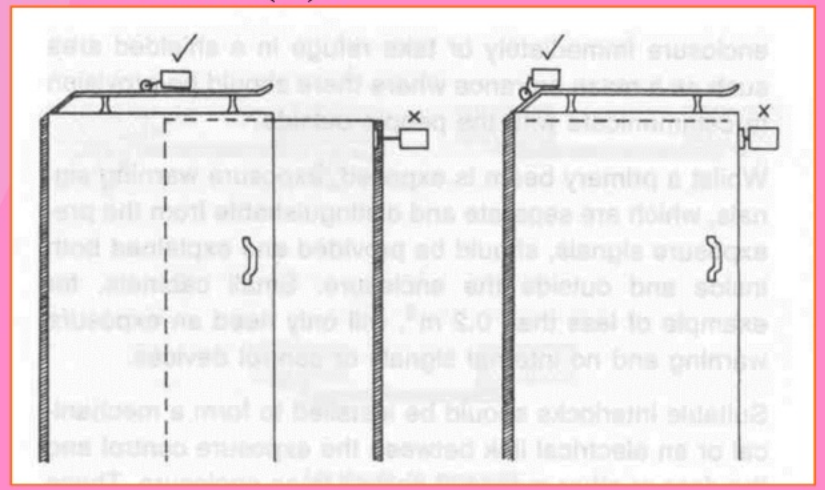
11.10.19 Tartu University Hospital C bunker

- All doors, gates, photoelectric beams and motion detectors must be interlocked to the treatment unit to prevent an exposure if a door is open.
- The interlock must also ensure that when the door is opened the irradiation will be terminated.
- The radiation output of the device should not be resumed automatically after the door is closed again.
- The interlock should be fail-safe so that safety is not jeopardized in the event of failure of any one component of the system.
- In certain countries (such as the United Kingdom), it is advised that a door-reset switch be situated near the exit from the treatment room at the position where the person leaving the room has a clear view of the room (4).

Doors:



Interlocks (3):



The purpose of a bunker is to reduce external dose rates to below the respective design dose constraints.

An average life span ~30 years, each linac is only in use for ~10 years.

Bunker size has to be large enough to allow full extension of the couch in any direction, with room for an operator to walk around it.

The desirable size depends upon the type of treatments (eg. TBI procedure will require a larger treatment distance to one wall) (2).

MAZE

DOORS AND INTERLOCKS

11.10.19 Tartu University Hospital C bunker

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

... is known as limited-access area in which the occupational exposure of personnel to radiation-producing equipment or radioactive materials is under the supervision of an individual in charge of radiation protection (NCRP 151 2005):

- treatment room,
- control console,
- adjacent treatment rooms.

Staff are trained in radiation protection techniques (2).

Controlled areas require access restrictions, interlock, warning signs, protective equipment and monitoring, staff to follow written procedures (7).

10.11.19 Tartu University Hospital treatment room C

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

... any other surrounding area, eg lobbies, offices, waiting areas, examining rooms, rest rooms, and outside areas.

The design goal is 1 mSv/year (recommended) (1).

Radiotherapy waiting area at Tartu University Hospital

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

Paragraph I.23 of the BSS requires registrants and licensees to *"display a warning symbol, such as that recommended by the International Organization for Standardization (ISO) …at access points and other appropriate locations within controlled areas."*

It is recommended that an illuminated warning sign be displayed at the entrance to the maze or treatment bunker as well as several inside the treatment bunker.

It should be possible to see a warning sign from any position within the treatment bunker.

These signs should be mounted at eye level (1650 mm above finished floor level) and interlocked with the treatment unit control

The radiation warning sign is that recommended by the ISO (4).

Photo from Tartu University Hopital

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

Purpose of monitoring and exposure assessment is to gather and provide information on the actual exposure of workers and to confirm good working practices contributing to reassurance and motivation (6).

BSS requires individual monitoring for any worker who is normally employed in a controlled area and who may receive a significant occupational exposure:

- Radiation oncologists;
- Qualified experts in radiotherapy physics (medical physicists);
- Radiotherapy technologists;
- Source handlers;
- Radiation protection officers;
- Maintenance staff;
- Nursing or any other staff spending time with patients.

Individual external doses can be determined by using individual monitoring devices (TLD or film badges) worn on the front of the upper torso and an assumption is made that the whole body is uniformly exposed (6).

TLD from Tartu University Hospital

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

1. Stuctural shielding design and evaluation for megavoltage x- and gamma-ray radiotherapy facilities. NCRP report no. 151
2. Morrow A M 2019 Radiation Shielding and Bunker Design
3. IAEA Training Material on Radiation Protection in Radiotherapy. Part 7. Design of Facilities and Shielding. Lecture 2: Shielding.
4. IAEA 2006 Safety reports series No. 47. Radiation Protection in the Design of Radiotherapy Faxilities.
5. https://www.radiation-therapy-review.com/Classification_of_areas.html
6. Ortiz-Lopez P, Rajan G and Podgorsak E B 2012 Radiation Oncology Physics: A Handbook for Teachers and Students
7. IAEA Training Material on Radiation Protection in Radiotherapy. Part 8. Occupational Exposure.
8. Fisher D R, Fahey F H 2017 Appropriate Use of Effective Dose in Radiation Protection and Risk Assessment Health Phys 113:102-109.
9. Abdullah M A H, Rashid R S M, Amran M, Hejazii F, Azreen N M, Fediuk R, Voo Y L, Vatin N I, Idris MI 2022 Recent Trends in Advanced Radiation Shielding Concrete for Construction of Facilities: Materials and Properties Polymers 14:2830

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital

OAMK
OULU UNIVERSITY OF APPLIED SCIENCES

Metropolia
University of Applied Sciences

HESAV
HAUTE ÉCOLE DE SANTÉ VAUD

TARTU TERVISHOIU KÕRGKOOL
TARTU HEALTH CARE COLLEGE

EBreast II

Co-funded by the Erasmus+ Programme of the European Union

Western Norway University of Applied Sciences

Tartu University Hospital

HELSE BERGEN
Haukeland University Hospital

Hes·so
Haute Ecole Spécialisée de Suisse occidentale
Fachhochschule Westschweiz
University of Applied Sciences and Arts Western Switzerland

Shielding and Occupational Exposure in Radiotherapy

EBreast II

1. Introduction
2. Background
3. Bunker shielding materials
4. Bunker design
5. Controlled areas
6. Uncontrolled areas
7. Warning signs
8. Monitoring
9. References
10. Partners

Author: Liis Randle
Tartu Univeristy Hospital