Radiation Safety Training Module: Diagnostic Radiology

Radiation Safety for X-ray Technologist in Diagnostic Radiology

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Radiological Safety Division
Atomic Energy Regulatory Board

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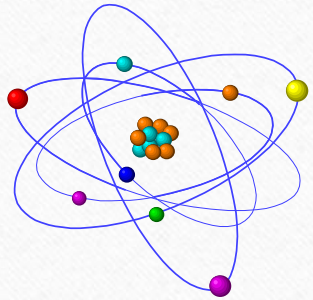
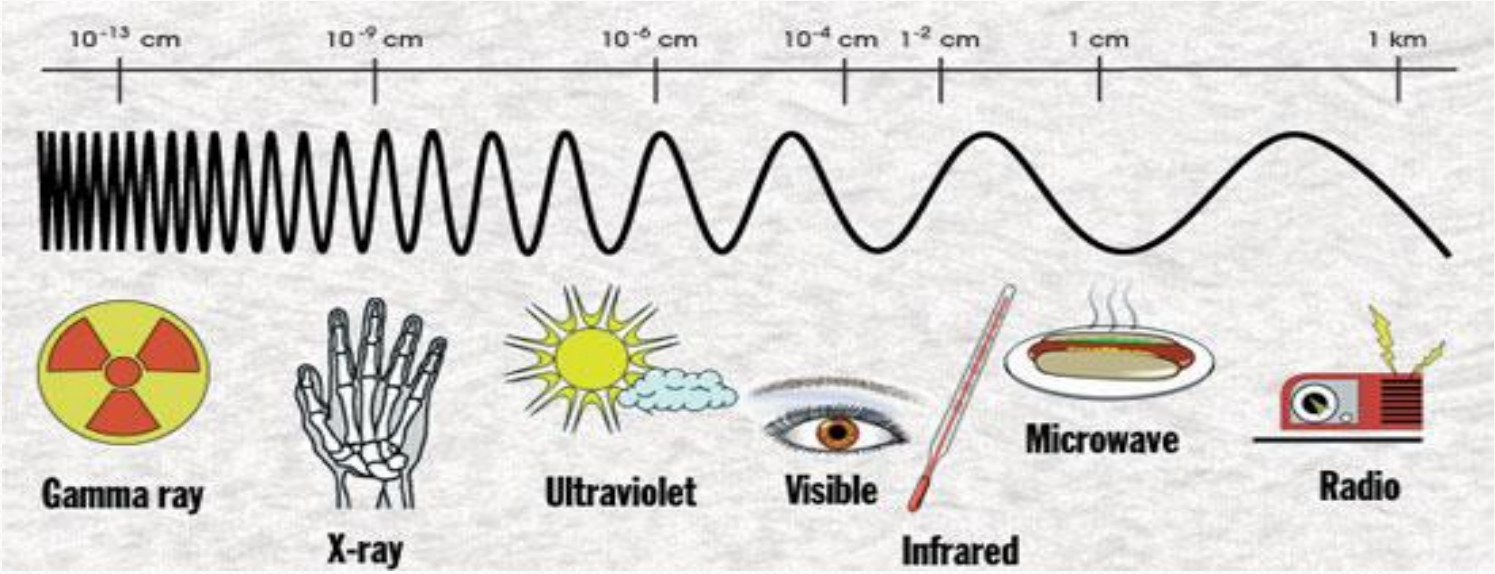
Radiation and its Types

Radiation: energy in motion

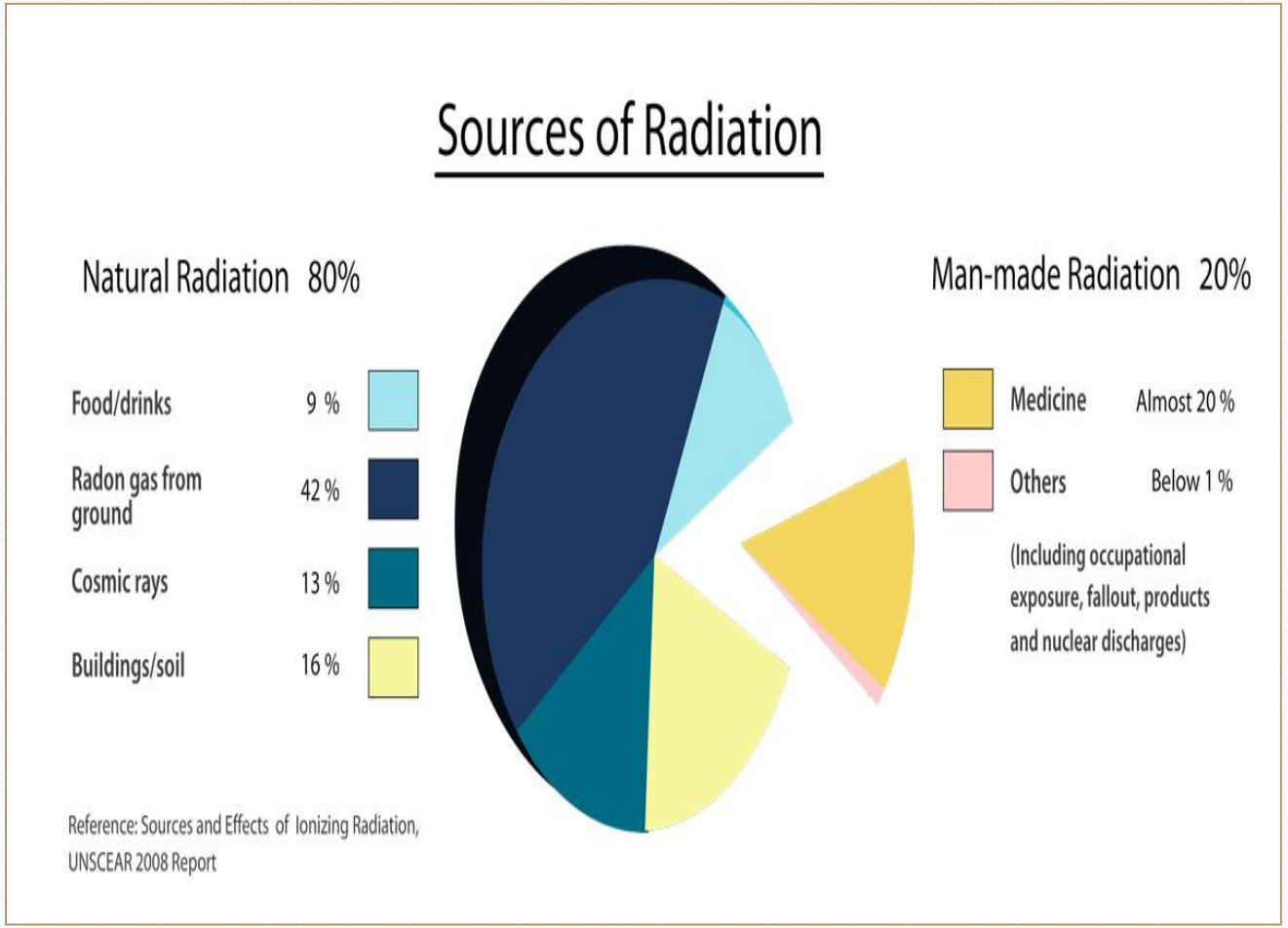


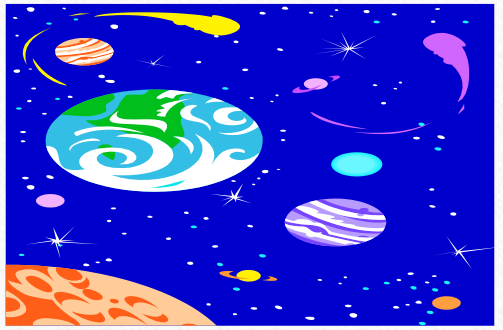
- **Non-Ionizing Radiation**: Radiation that does not have sufficient energy to eject orbital electrons. e.g.: microwaves, ultraviolet light, lasers, radio waves, infrared light, and radar.

- **Ionizing Radiation**: Radiation that has sufficient energy to eject orbital electrons. e.g.: alpha particles, beta particles, neutrons, gamma rays, and x-rays.



Radiation Exposures to Population





- **Amongst man made radiation sources, Medical diagnostic x-ray examinations contribute the largest dose to population.**

WHY TO ADDRESS RADIATION SAFETY IN USE OF X-RAYS

- **ANNUAL GLOBAL X-RAY EXPOSURES**
  - Diagnostic X-ray Examinations : 3.1 billion
  - Dental X-ray Examinations : 0.5 billion
  - Collective effective dose : $4X10^6$ man-Sv
  - Effective dose per person : 0.62 mSv
  - Contribution due to CT scans : 43% of collective dose
  - Contribution due to IR procedures : 8 % (during last 10 years)

Diagnostic X-ray examinations in 1996 : 2.4 billion

Data Source: UNSCEAR Report 2008

Mission of the AERB

The Mission of the AERB is to ensure the use of ionising radiation and nuclear energy in India does not cause undue risk to the health of people and the environment.

The constitution of AERB together with the Atomic Energy (Radiation Protection) Rules, 2004, has mandated AERB to develop and issue safety codes and standards and to develop safety policies in radiation and industrial safety areas.

Biological Effects of Radiations

Deterministic effects:

There is a threshold dose below which no effect is observed

Above this threshold the severity of the effect increases with dose.

- *Temporary Sterility*
- *Epilation*
- *Nausea, Vomiting and Diarrohea (NVD syndrome)*
- *Erythema*
- *Cataract*
- *Skin burn*

Whether working in an X-ray facility can cause any of these effects: NO

Whether working in an IR facility can cause any of these effects : NO (with proper use of safety accessories)

Stochastic / Probabilistic effects

❖There is no established threshold dose.

❖The probability of the effect increases with dose.

- Cancer
- Leukaemia
- Hereditary effect

No threshold dose is defined !!

Stochastic Effects	Deterministic Effects
Due to cell changes (DNA) and proliferation towards a malignant disease	Due to cell killing
No dose threshold- applicable also to very small doses	Involve a large number of cells
Probability of effect increases with dose	Have a dose threshold -typically several Gy
Severity (example cancer) independent of the dose	Specific to particular tissues
	Severity increases with dose eg. Skin injuries

RADIATION SAFETY PROGRAMME SHOULD BE DESIGNED TO

1. PREVENT DETRIMENTAL DETERMINISTICS EFFECTS

II. LIMIT or MINIMIZE THE PROBABILISTICS EFFECTS TO LEVELS OF ACCEPETABLE

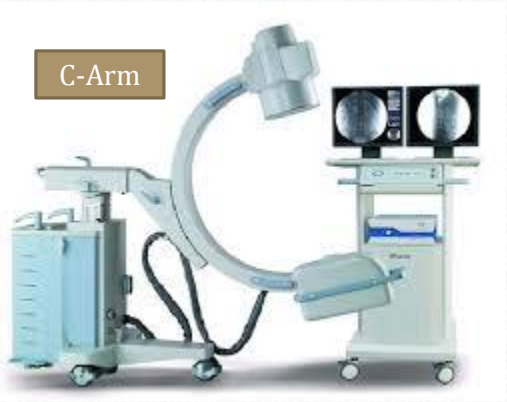
Types of Different Modalities Diagnostic Radiology Equipment

- Computed Tomography
- Interventional Radiology
- Radiography (Fixed/Mobile)
- C-Arm/ O-Arm
- Mammography
- BMD
- Dental (Intraoral/OPG/CBCT)

Note: MRI and Sonography (Ultrasound) or non- ionising RGE do not come under purview of AERB regulations

Equipment's used in Diagnostic Radiology Facilities

Radiography (fixed)



C-Arm

Interventional Radiology

Dental (OPG)

Computed tomography

Dental (intra-oral)

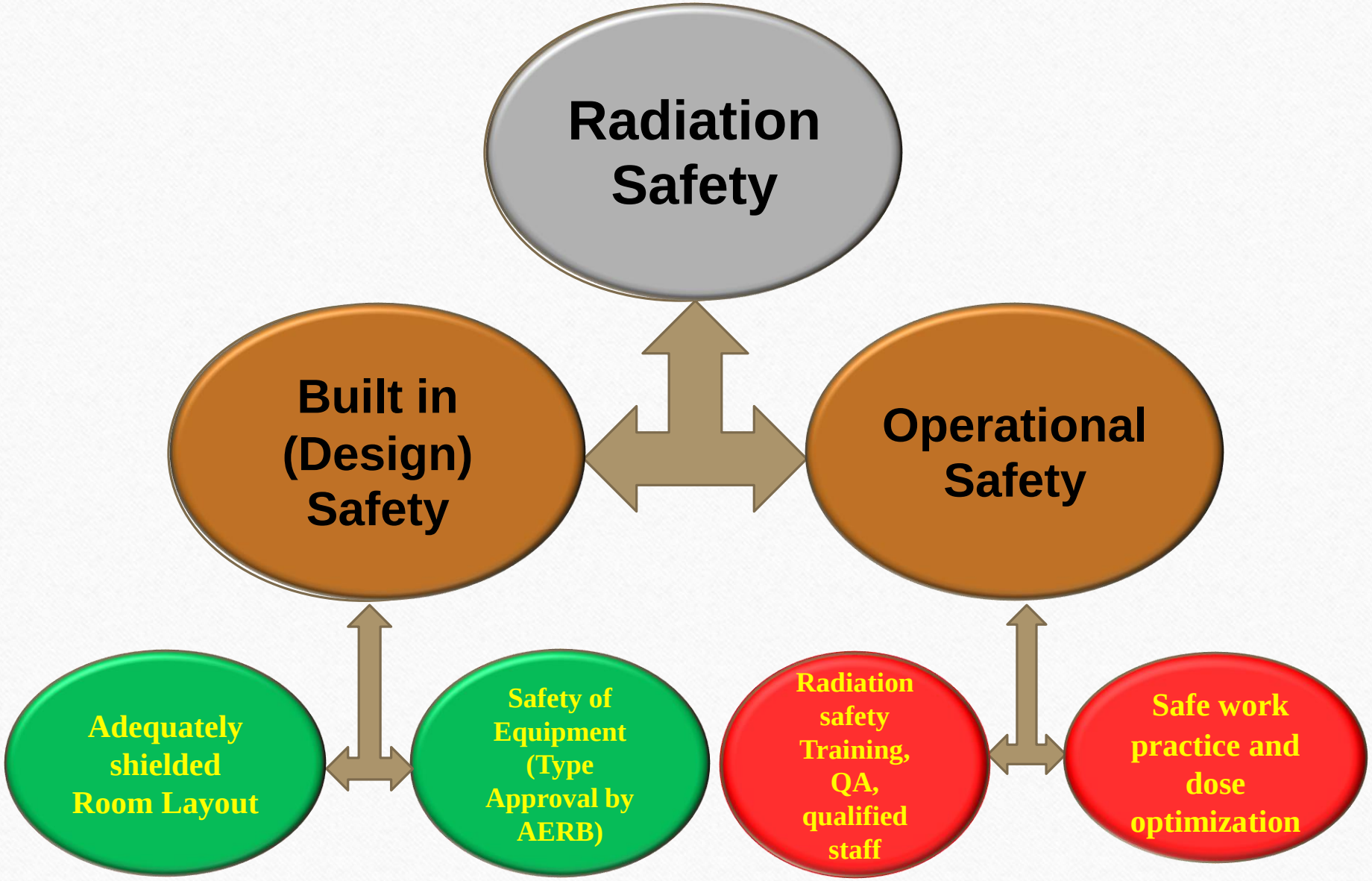
Mammography

BMD

Typical Patient Doses in X-ray Procedures

Procedure	Effective Dose mSv	Increased Risk of Cancer	Equivalent Period of Natural Background
Low Dose			
• Chest X ray • Extremities	<0.1	One in a million	Few days
Intermediate Dose			
• IVP • Lumbar spine • Abdomen • CT head and neck	1 - 5	1 in 10,000	Few months to a few years
Higher doses			
• Chest or abdomen CT • Nuclear cardiogram • Cardiac angiogram • Barium enema	5 - 20	1 in 2,000	Few years to several years
Natural background	2.4	-	-

Ref: IAEA: Radiation Protection of Patients (RPOP)


Radiation Safety
Built in (Design) Safety
Operational Safety
Adequately shielded Room Layout
Safety of Equipment (Type Approval by AERB)
Radiation safety Training, QA, qualified staff
Safe work practice and dose optimization

Operational Safety

Components of operational safety

- Handling of equipment by Qualified persons
- Usage of Personnel monitoring (TLD)
- Preventive maintenance (QA) of equipment
- Interaction with regulatory body
- Use of safety accessories -
  - Mobile Protective Barrier, Lead Apron, Organ shield etc.

Built-in Radiation Safety

Design Safety of the Equipment:

Install only those equipment that are Type Approved by AERB

Take requisite AERB permissions prior to installation

Ensure the performance evaluation of the equipment is acceptable after installation

Use the equipment after obtaining license for operation

Design Safety of Installation:

Install the equipment in an adequately shielded room

Ensure all the equipment specific safety (such as ceiling suspended lead glass, couch hanging lead rubber flaps etc) accessories are provided

Refer Model Layout of X-ray installations provided on AERB web site

Basic Principles of Radiation Protection

1) JUSTIFICATION: No practice shall be adopted unless its introduction produced a net positive benefit

2) OPTIMIZATION OF EXPOSURES: All exposures shall be kept As Low As Reasonably Achievable (ALARA), economic & social factors being taken into account

3) DOSE LIMITS: Dose to individuals shall not exceed recommended limits (Applicable to occupationally exposed personnel)

Exposure due to natural background radiation & medical exposure excluded in arriving at the dose limits.

Dose Limits prescribed by the Competent Authority in India

Part of the body	Occupational Worker	Member of Public	Trainee
Whole body (Effective dose)	20 mSv/year averaged over 5 consecutive years; 30 mSv in any single year	1 mSv/year	6mSv in a year
Lens of eyes (Equivalent dose)*	150 mSv in a year	15 mSv/year	50 mSv in a year
Skin (Equivalent dose)	500 mSv in a year	50 mSv/year	150 mSv in a year
Extremities (Hands and Feet) Equivalent dose	500 mSv in a year	----- -----	150 mSv in a year

For female workers , once pregnancy is declared the equivalent dose limit to embryo / fetus shall be 1 mSv for the remainder of the pregnancy.

ICRP has recently revised the dose limit for lens of eyes as 20mSv in a year for occupational workers

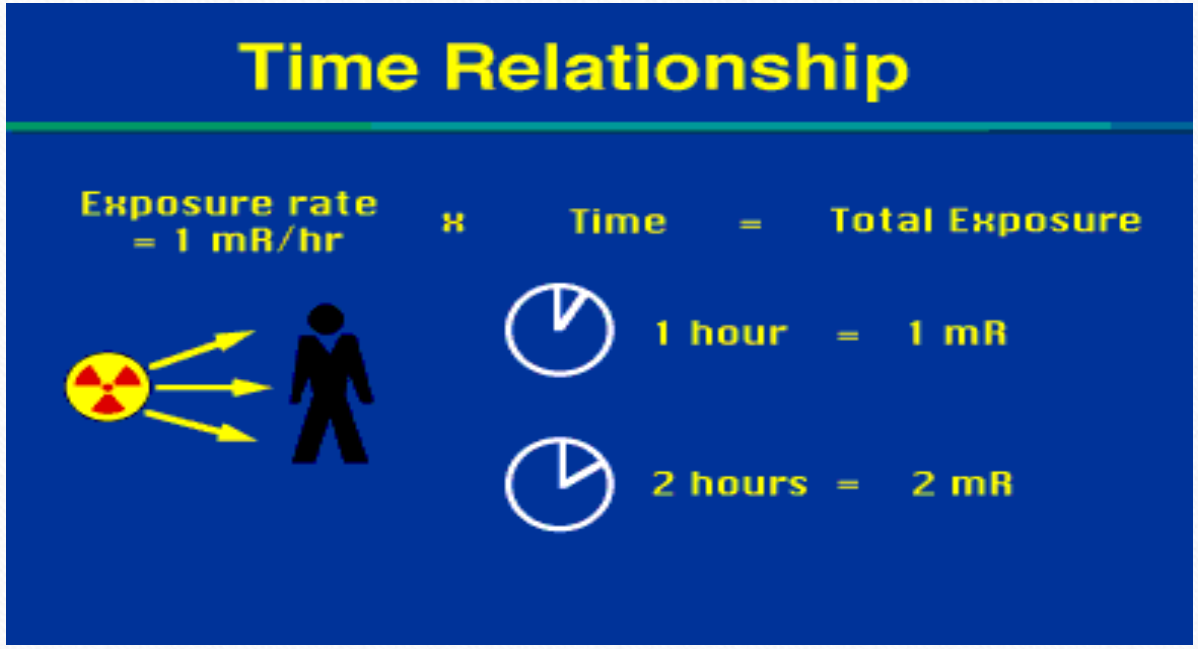
Basic Three Factors for Radiation Protection (Working Personnel & Public)

- Time
- Distance
- Shielding

TIME

- Exposure from X-ray unit is directly proportional to time

- *Reduce period of exposure to radiation to reduce the dose received from source.*



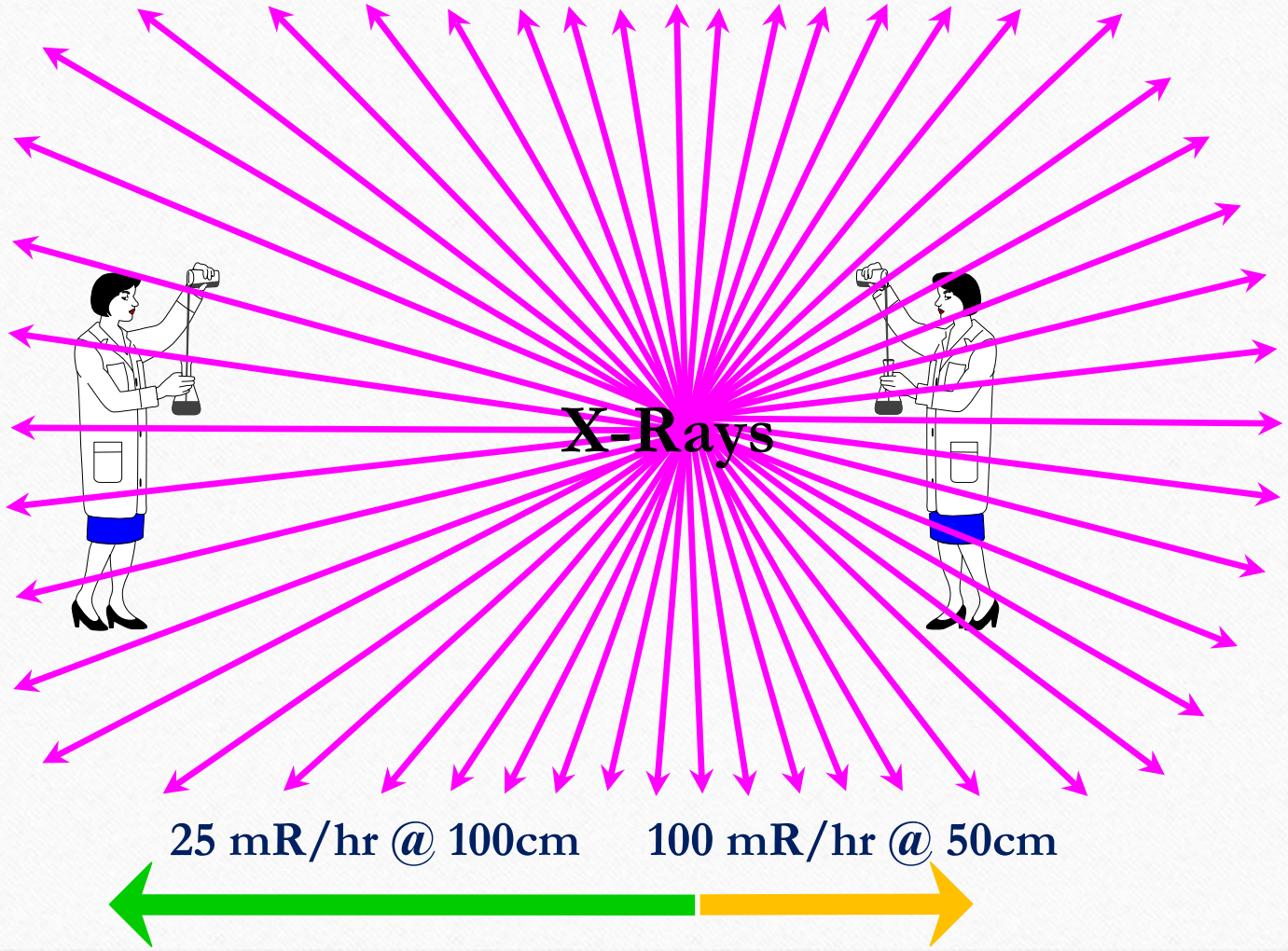
DISTANCE

- Increase distance from source to decrease exposure rate.
- $I_1 d_1^2 = I_2 d_2^2$ (INVERSE SQUARE LAW))
- Double the distance from the source; dose-rate falls to ¼ the original value.
- Halve the distance from the X ray source; dose-rate increase to 4 times the original value.

More the distance from source (X-rays) -Lesser the radiation

Effect of Distance on Dose Rate-Inverse Square Law:

Increase Distance



SHIELDING

Use an appropriate shielding material or protection devices

$I = I_0 e^{-\mu t}$

μ-linear attenuation coefficient

USE LARGE SHIELDING THICKNESS (High Z materials eg Lead, Steel etc)) -REDUCE THE EXPOSURE RATE

To reduce the Radiation dose to the individual-

- Reduce the time of exposure
- Increase the distance from the X-ray source
- Interpose a shielding material between source and working person-- **(Use of radiation protection accessories)**

Radiation Protection Accessories of Operator/Staff

Lead Apron/lead equiv. glass eyewear

✓Use protective devices

✓use of lead apron (0.25 mm lead equivalent)

0.25 mm Lead Eqv. glass eyewear with side protection

Radiation dose would be reduced by more than 90 % by using lead apron

Use TLD with the cassette
Wear TLD below apron, at the Chest Level

Use ceiling suspended screens, lateral shields and table curtain in fluoroscopy procedure.

Should not be removed

90% protection from scattered radiation

Proper storage of radiation protection devices-Lead apron

Proper storage maintains good quality of the lead apron Shielding adequacy of the lead apron should be checked atleast Once in two years

Use of TLD Badge

What is TLD Badge

TLD Badge is a radiation dose measuring device. This provides us to know if we are working with in the safe limits (TLD does not protect us from radiation)

What is Your TLD Badge Number

000297C0198/
000297W0198

Use TLD with cassette

TLD with cassette

TLD with out cassette

The Cassette has three windows with different filters for estimation of radiation doses from different types of radiation. Wearing a BARE TLD card will give a very WRONG estimation of the dose

Wear TLDs below Lead Apron

TLD below apron

TLD above apron

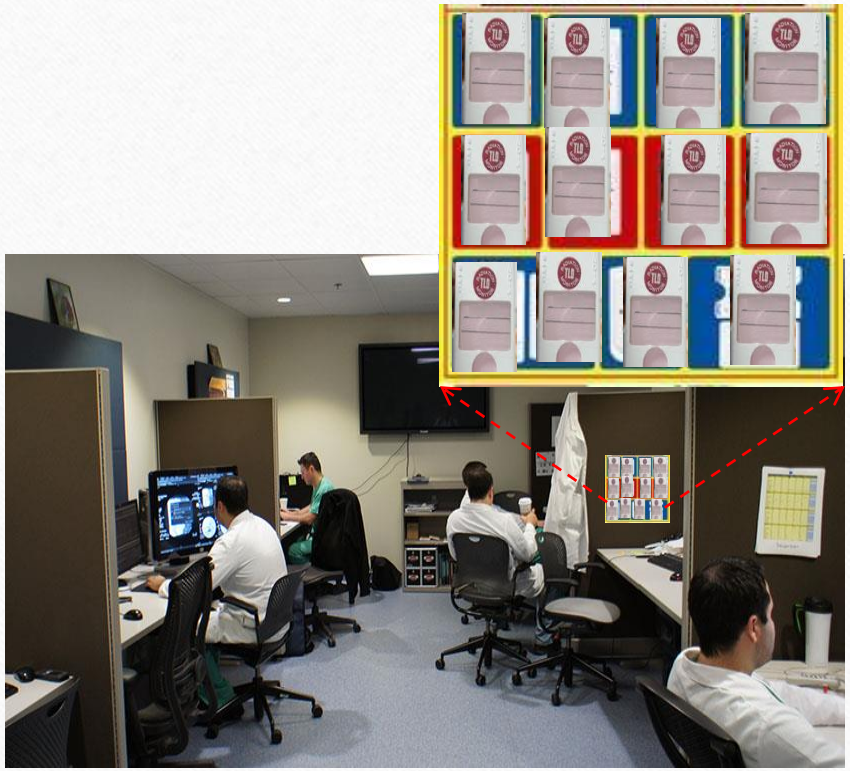
The lead apron provides protection from radiation. Wearing a TLD below lead apron estimates the actual received dose by radiation worker. Above lead apron will give a very WRONG estimation of the dose.

Where to Store TLD badge

Never store/ leave TLD badges (control/ personnel) in X-ray Room/Radiation Area.

Storing of TLD badge in radiation area after work, provides unnecessary exposure i.e. non-genuine dose to TLD badge

Store control TLD badge in radiation free area all the time. Store personnel TLD badge in radiation free area when not in use. (e.g., office room)



Radiation Protection Accessories

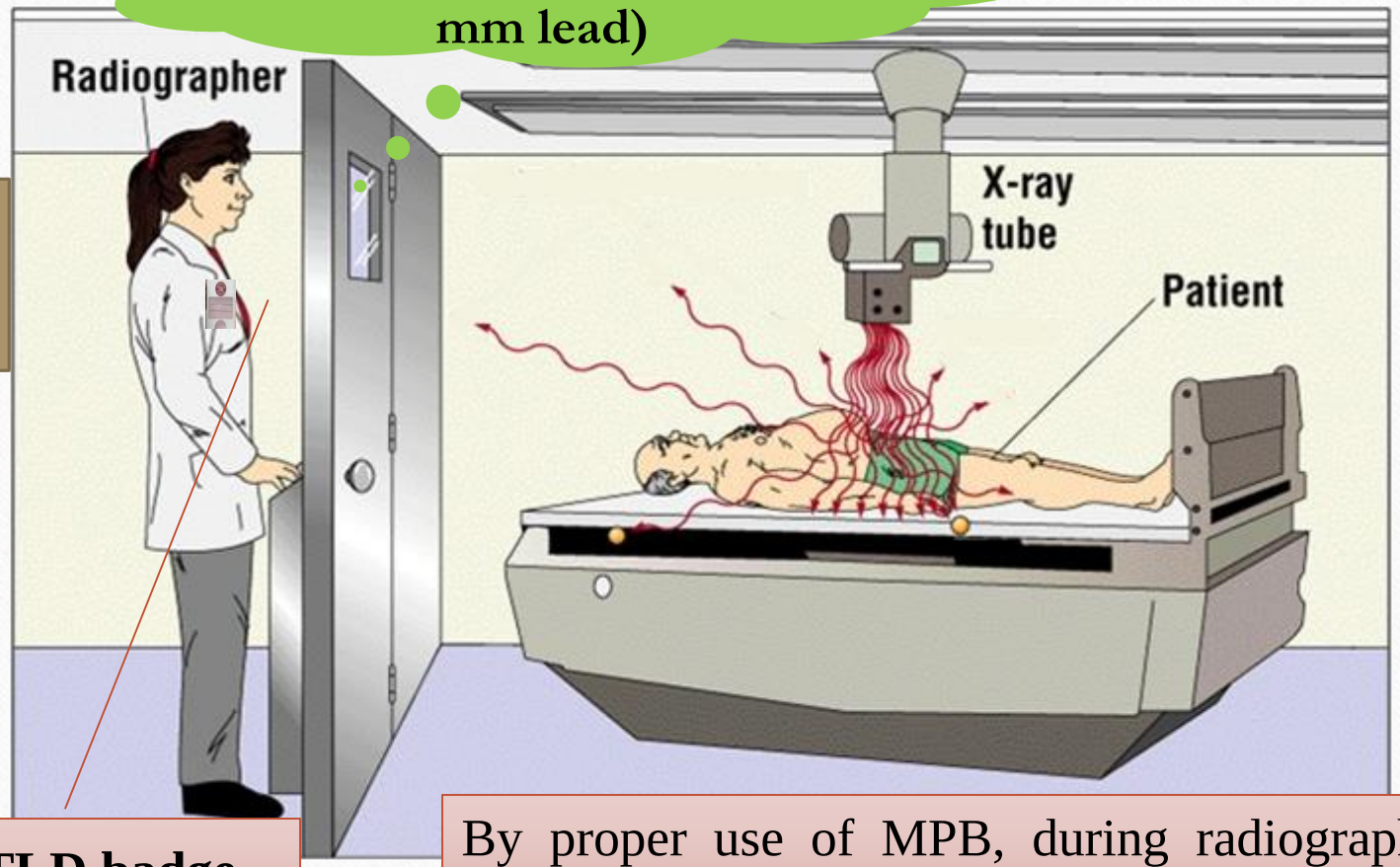
- Mobile Protective Barrier (MPB)- 1.5 mm Lead Eqv
- Lead Aprons - 0.25 mm Lead Eqv
- Thyroid Shield -0.25 mm Lead Eqv
- Gonads Shield- 0.25 mm Lead Eqv
- Eye Wear (Shield)- 0.25 mm Lead Eqv
- Rubber hanging Flaps (In IR)-0.5 mm Lead Eqv
- Hand Gloves -0.25 mm Lead Eqv
- Lead Glass window- 1.5 mm Lead Eqv
- Door (Lead Lined)-1.7 mm Lead Eqv

Accessories provide the shielding which will drastically reduce the radiation dose to operator.
Never forget to use them

Radiation Safety in Radiography

Always work behind a protective barrier (min. 1.5 mm lead)

Use of Mobile Protective Barrier (MPB)



Wear TLD badge at the chest level

By proper use of MPB, during radiographic procedures technician/operator is protected from scatter and leakage radiation.

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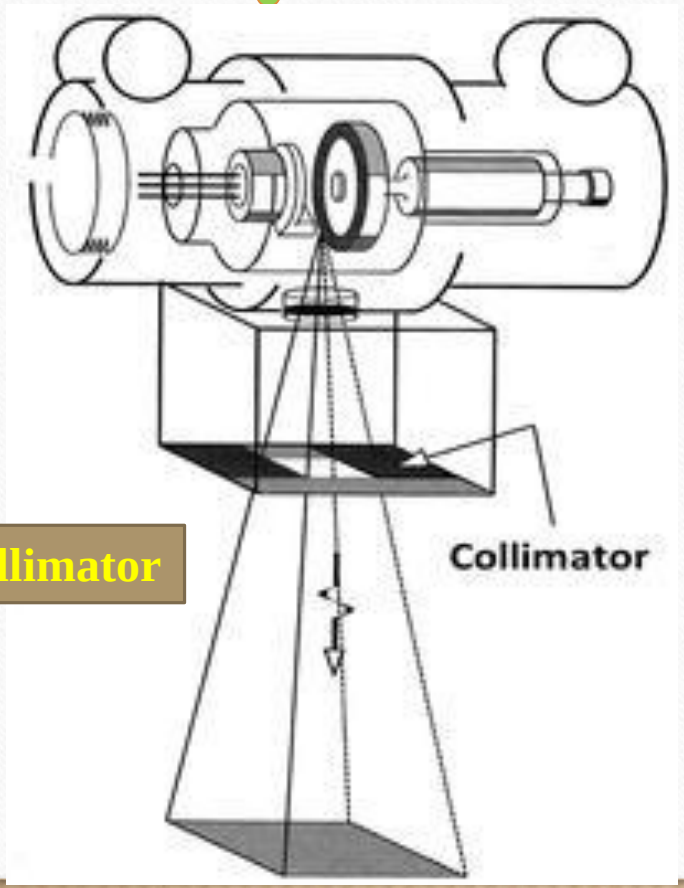
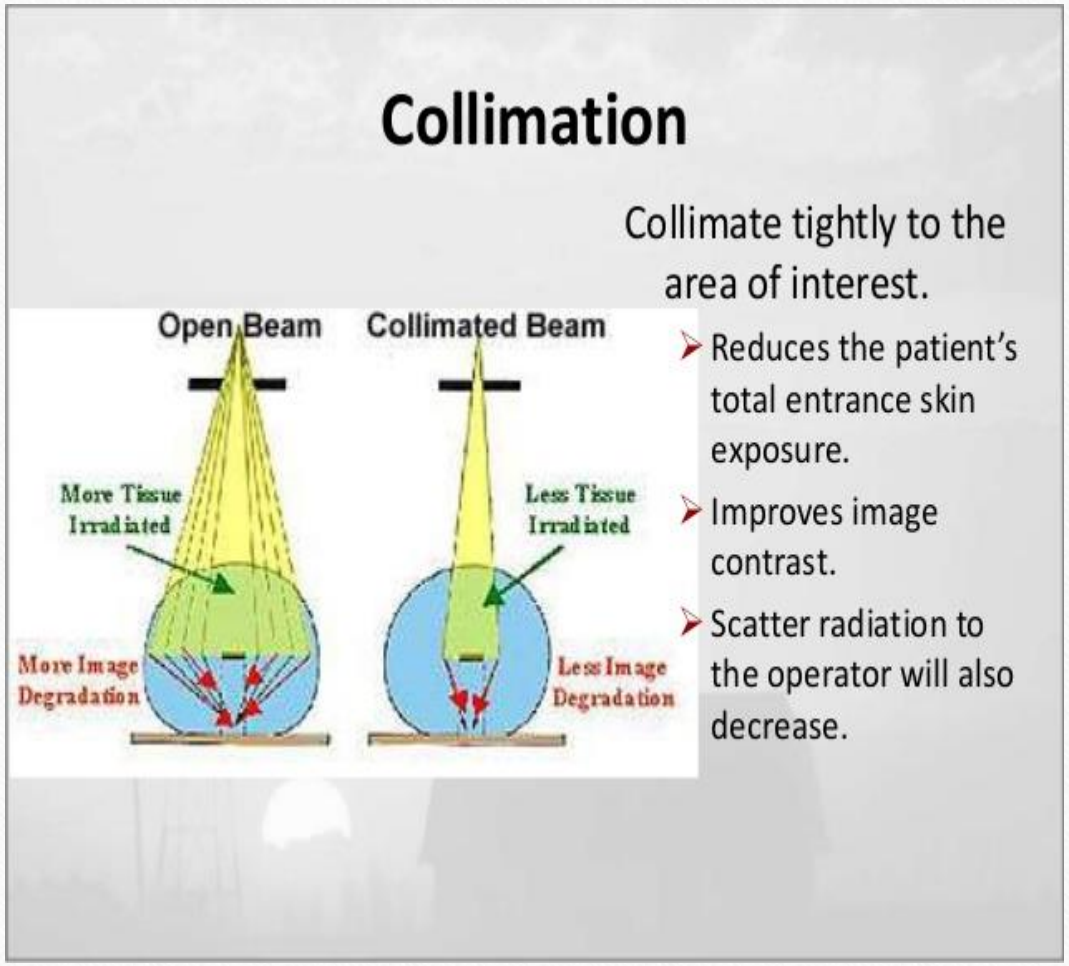
use collimator (diaphragm) to limit the field size to the area of interest



Use of Collimator



Use of Antiscatter Grids

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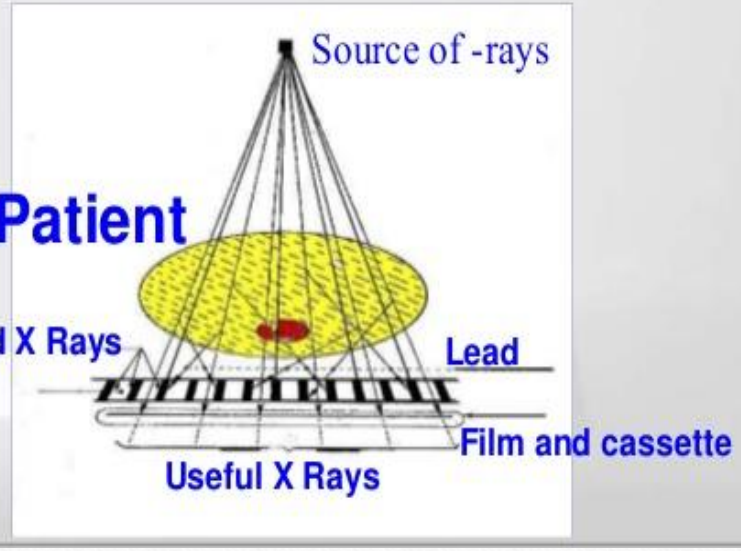
- **Antiscatter grids**

Antiscatter grids reduce scattered radiation reaching the film thus improving the quality of the resulting the radiograph and reducing chances of repeat exposures.



Antiscatter grids increase the radiation dose to patient and hence where required use the grids. For pediatric patient do not use grids.

Radiation Safety in Mobile Radiography

Use of appropriate cable length and lead apron

Operate the mobile X-ray machine from a distance using control cable of 2 m length, Use Lead Apron

Always use TLD at the chest level, inside lead apron

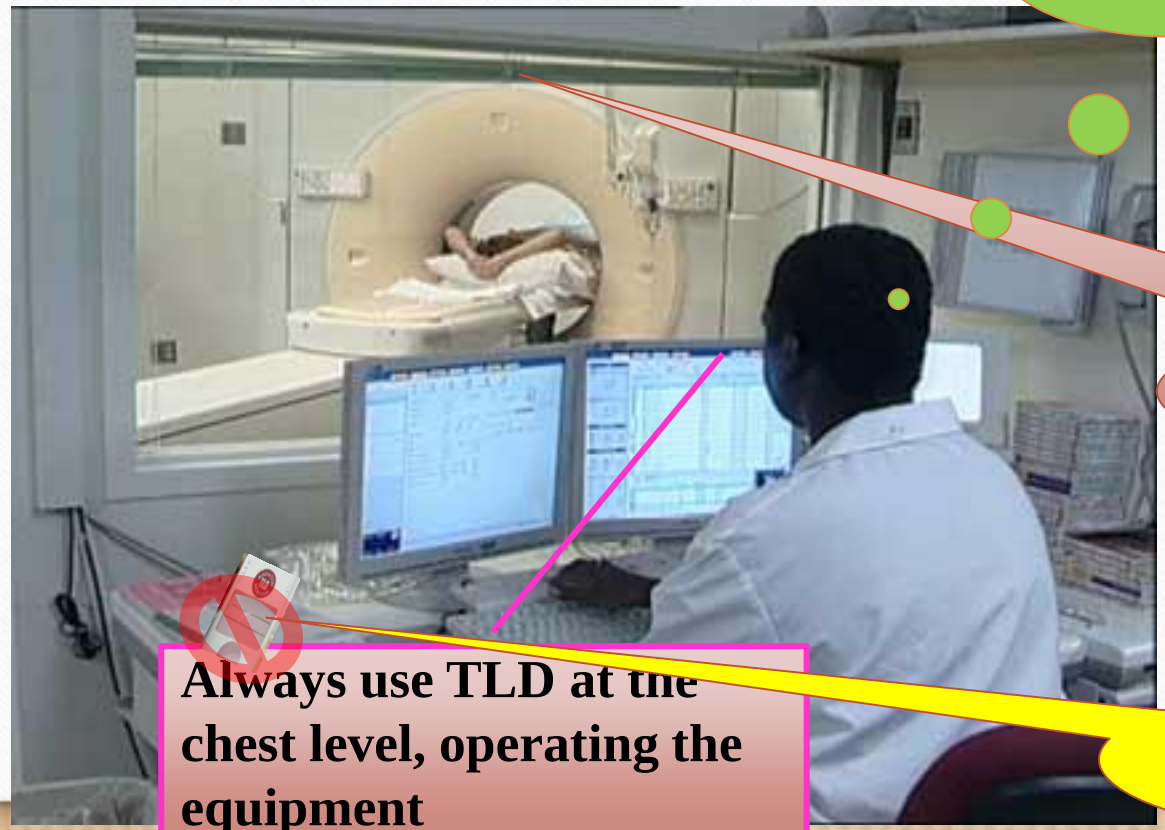
Extendable Control Cable

By using 2m cable, distance increases and radiation exposure reduces

Radiation Safety in Computed Tomography

Mandatory requirement of separate control room

Operate the CT equipment from the control room



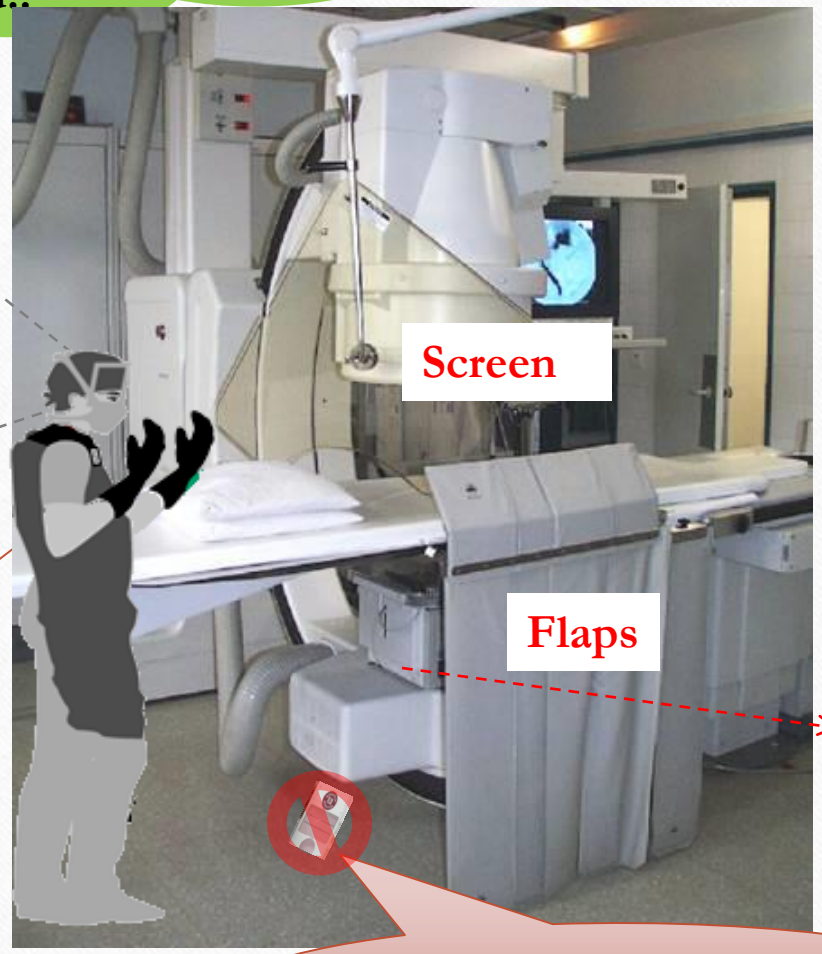
2 mm lead equivalence viewing window

Always use TLD at the chest level, operating the equipment

Never leave TLD badge at control room after work

Use Ceiling Suspended screen, couch hanging flaps and Lead Apron, Lead glasses , Thyroid shield..

90% protection from scattered radiation



Radiation Safety in Interventional Radiology

Always use TLD at the chest level, inside lead apron

Keep X ray tube under the patient table and not over it

Never leave TLD badge near the X-ray equipment

Radiation Safety in Mammography

Use of Mobile Protective Barrier(MPB)

Operate the mammography machine behind mobile barrier

Mobile barrier of min.1.5 mm lead equivalence

Radiation Safety in Dental Radiography

Ensure availability of Lead lined cone for the dental-IOPA X-ray unit

Proper shielding of dental cone

Plastic Cone should not be used

Ensure that the Cone is lead lined. Plastic Cone increases the radiation dose to patient and worker and should not be used

Use of Mobile Protective Barrier(MPB) to operate dental OPG/CBCT if separate control not available

stand behind the protective barrier during operation

keep the TLD badge away from radiation area when not in use

Cont'd

TLD badge below the lead apron

PATIENT PROTECTION

Radiation safety of patient is ensured by

- ✓ Limiting the total “beam–on” time in flouroscopic procedures
- ✓ Avoiding oblique lateral projections (especially in flouroscopy and IR)
- ✓ Collimation to limited field size – Area of Interest
- ✓ Selecting low dose protocol whenever feasible (High kV and Low mAs)
- ✓ Use of Exposure protocols for patient examinations including paediatric protocols
- ✓ Monitor the DLP in CT and DAP values for IR procedures
- ✓ Maintain the Record of of patient’s doses for CT and IR procedures.

More points to Remember

- Carry out QA testing of each & every X-ray equipment once in TWO YEARS to maintain the quality of equipment and imaging standard.
- Use equipment “Type Approved” by AERB. Type Approved Comply with design safety requirements
- Operate X-ray equipment which is licensed by AERB
- If new X-ray equipment is being purchases, do it only after taking “Procurement Permission” from AERB
- Do a Radiation Protection Survey report (RPS) of X-ray facility to ensure radiological safety of the installation

TRY THESE..

1. What are the basic factors for radiation protection in Diagnostic radiology?

Ans: Time, Distance & shielding

2. What is the relation between distance & X-rays exposure?

Ans: X-ray exposure follows inverse square law with distance-$I_1 d_1^2 = I_2 d_2^2$

3.What are the different types of radiation protection accessories to be used during the diagnosis of patients?

Ans: Lead apron, protection barrier, lead eye glass, gonad shield, hand gloves, thyroid shield etc.

4. Where to store the TLD badge after the routine work.

Ans: In radiation free area (Outside the X-ray installation room)

5. What is the mission of AERB?

Ans: The Mission of the AERB is to ensure the use of ionising radiation and nuclear energy in India does not cause undue risk to the health of people and the environment

6. What are the common shielding materials used for protection in Diagnostic Radiology?

Ans: Lead, Steel and brick, concrete etc

List of presentations in the training Module

Basics of Diagnostic X-ray Equipment
Biological effects of Radiations
Medical X-ray imaging techniques
Planning of Diagnostic X-ray facilities
Quality Assurance of X-ray equipment
Quality Assurance of Computed Tomography equipment
Radiation Protection in Diagnostic Radiology Practice
Causes, prevention and investigation of excessive exposures in diagnostic radiology
Regulatory Requirements for Diagnostic Radiology Practice

THANK YOU