Radiation Protection & Regulatory Control in Radiation Therapy

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HEAD

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What is in the presentation

- Radiotherapy facilities in India
- Basics of Radiation & its Protection
- Hazard Evaluation & Control
- Regulation of RT facilities in India

Radiotherapy Facilities in India

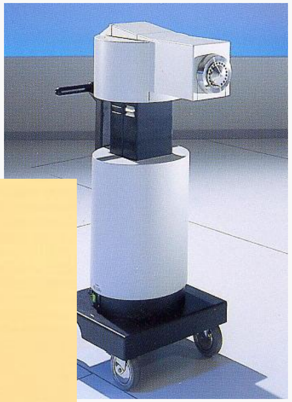
Teletherapy Facilities in India

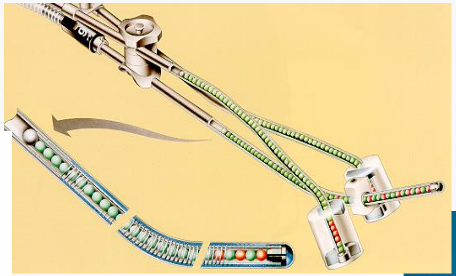
Radiotherapy Centres	: 500
Teletherapy Facilities	: 729
○ Co-60 Units	: 159
○ Linear Accelerators	: 534
○ Gamma Knife	: 6
○ Tomotherapy	: 22
○ CyberKnife	: 8

Brachytherapy Facilities in India

Brachytherapy Devices/Facilities : 387

- Remote Afterloading Units (HDR/MDR/LDR) : 318
- Manual Afterloading kits (Cs-137) : 35
- Facilities using Sr-90, Ru-106 and I-125 : 57
- Intra Operative Radiotherapy (IORT) unit : 01






Basics of Radiation & its Protection

Quantities &Units for Radiation Measurement

Exposure

Ionization produced in unit mass of air
Unit: C/Kg, Roentgen (R)

↓

Absorbed Dose

Energy Deposited in unit mass of medium
Unit: Gray (Gy), Rad

↓

Equivalent Dose

Effect of absorbed dose for radiation type
Unit: Sievert (Sv), Rem

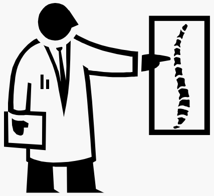
↓

Effective Dose

Effect of equivalent dose in tissue
Unit: Sievert (Sv), Rem

System of Radiological Protection

- Justification of practice



- Optimization of protection

- Limitation of doses

Basis for the Dose Limit

- **To prevent deterministic effects**

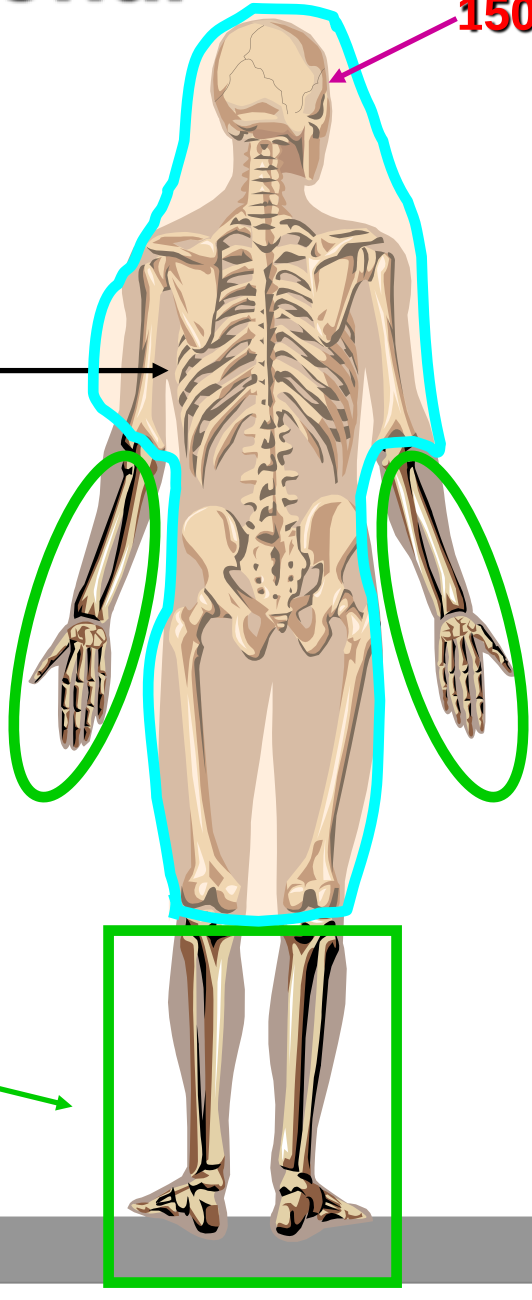
- **To reduce the probability of stochastic risk at an acceptable level**

Adult (>18 years) Occupational Dose Limits

Lens
150 mSv

Whole Body
30 mSv maximum per year
20 mSv averaged over 5 years

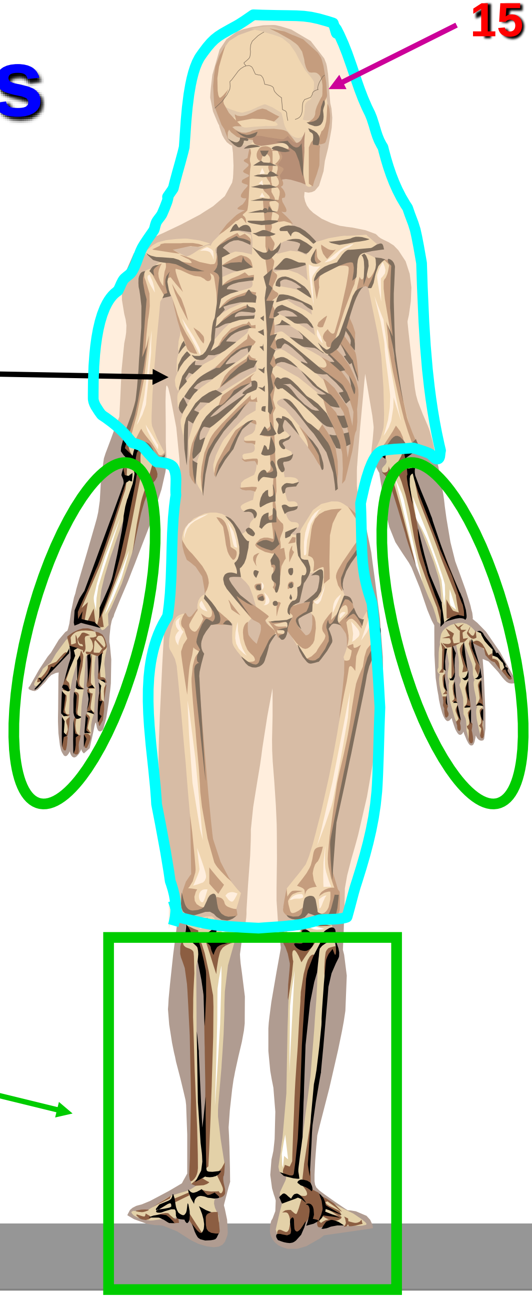
Extremities
500 mSv per year



Public Dose Limits

Lens
15 mSv

Whole Body
1 mSv per year

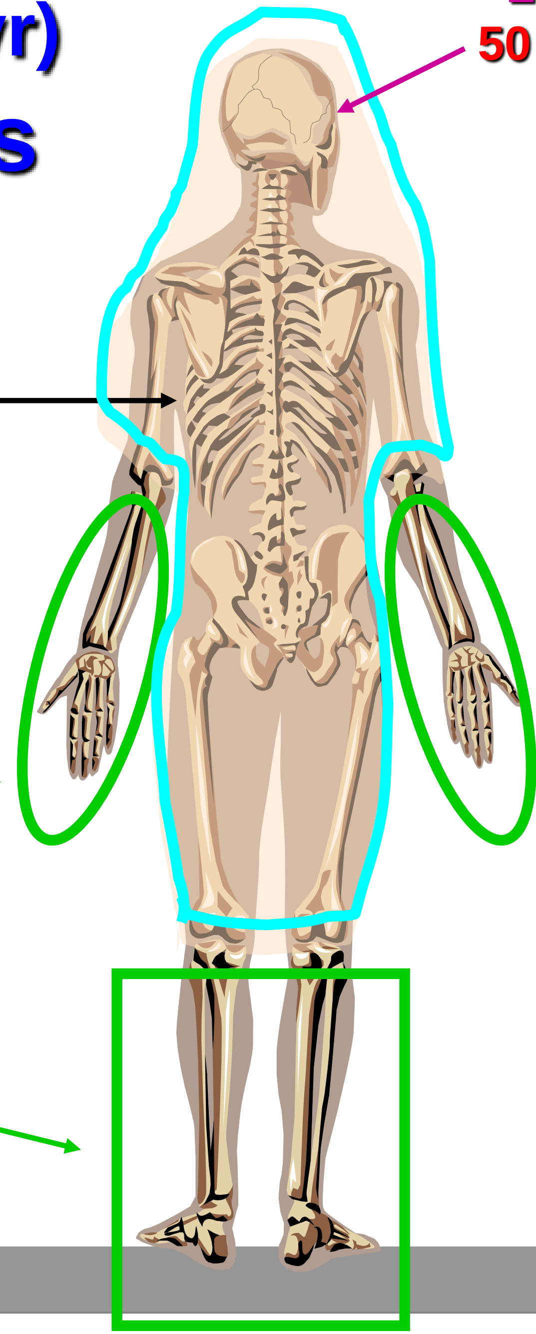


Extremities
50 mSv per year

Apprentice/Trainee (16-18 yr) Occupational Dose Limits

Lens
50 mSv

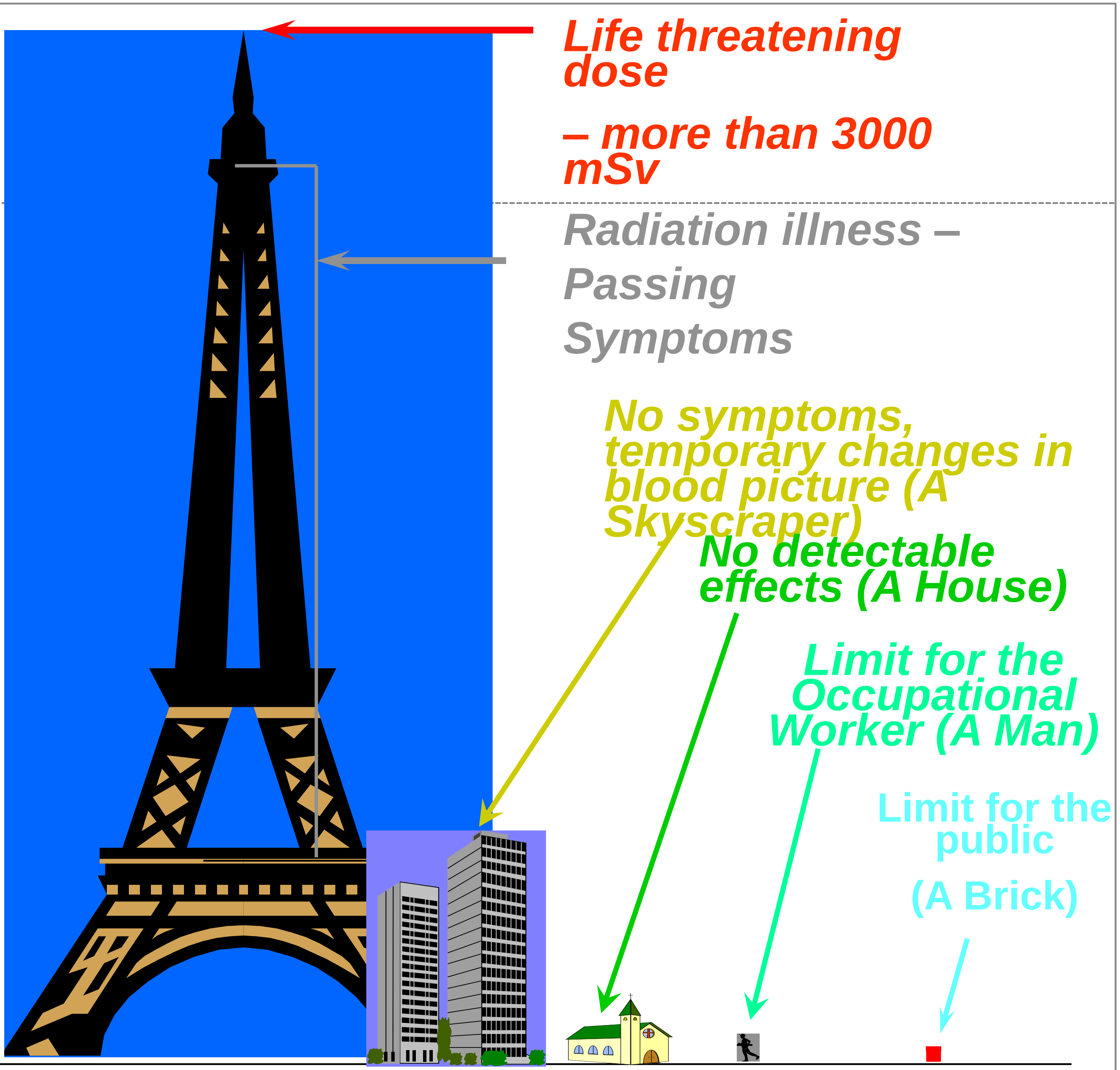
Whole Body
6 mSv maximum per year



Extremities
150 mSv per year

Exposure to Radiation Dose

If a life threatening dose (50% probability) is illustrated by the height of the Eiffel tower (over 300 meters), the dose limit for occupational (radiation) workers corresponds to the height of a man (2 meters) and the limit for the public to the thickness of a brick (0.1 meters).



Comparison of Risk

Accident type	Individual risk/year
Motor vehicle	1 in 4 000
Fires	1 in 25 000
Air travel	1 in 100 000
Electrocution	1 in 160 000
Lightning	1 in 2 000 000
Radiation Industry	1 in 5 000 000 000

Typical Average Annual Exposures

Practice	Average annual dose (mSv)
Industrial radiography	0.9
Nucleonic gauges	0.13
Gamma irradiators	not significant
Teletherapy	0.55
Brachytherapy	0.49
Nuclear medicine	0.54
Diagnostic radiology	0.49

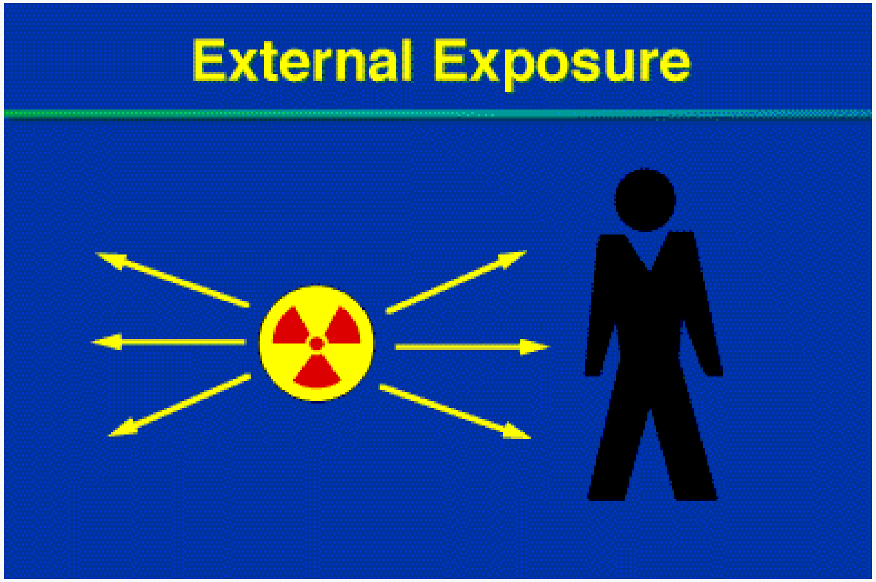
Basic Safety Objective

- Protection of occupational workers, patient, public and environment
- ALARA during normal operations
- Radiation exposure during normal operations within relevant dose limits
- Potential exposures and the magnitude of such exposures are kept ALARA

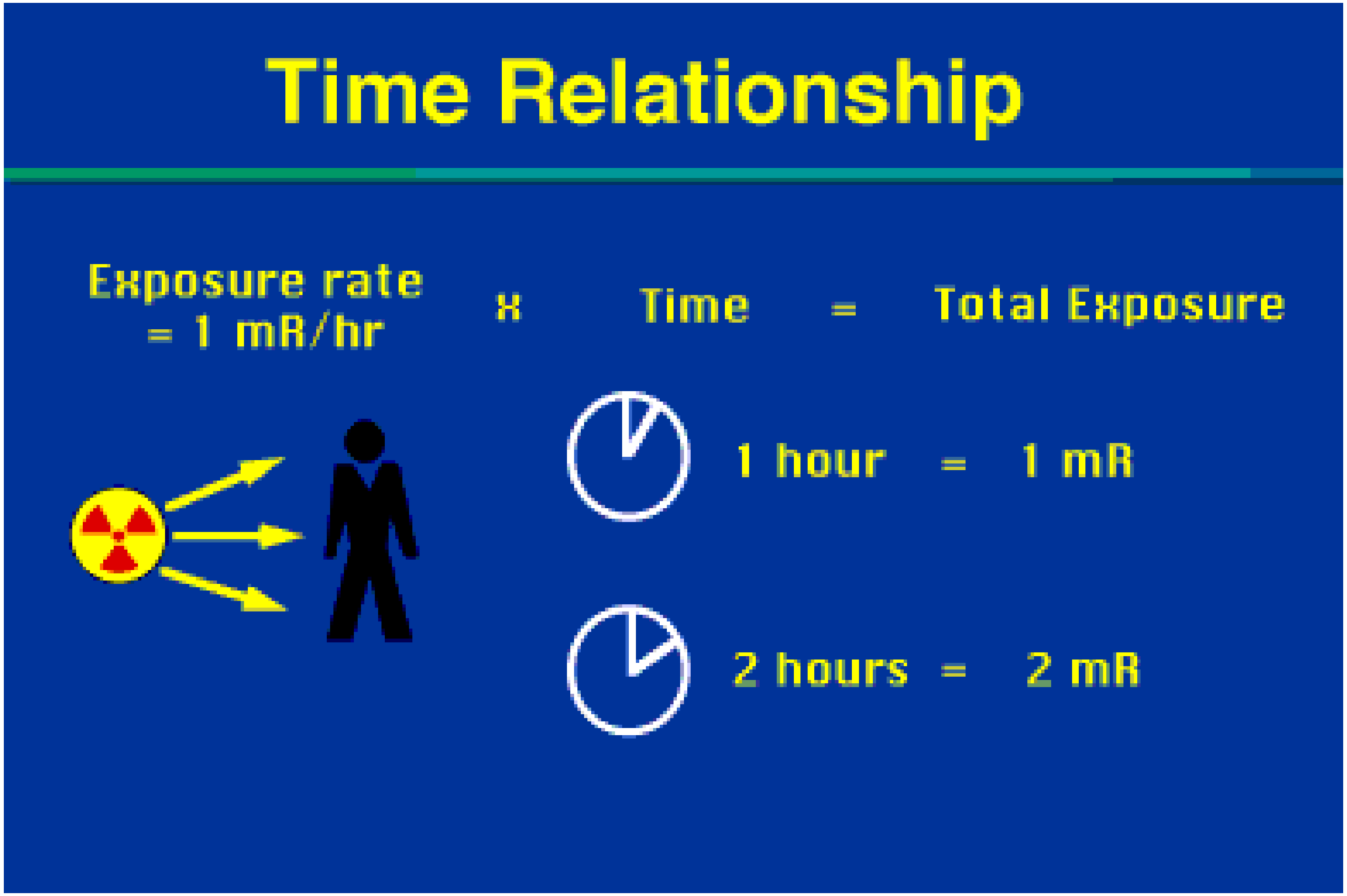
Hazard Evaluation & Control

Basic Radiation Protection Techniques

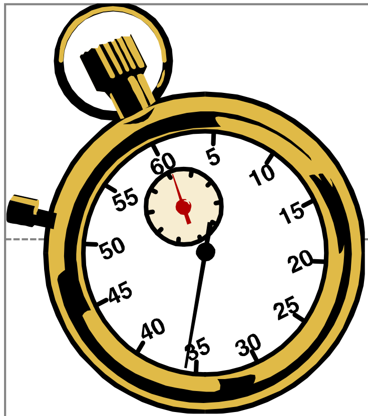
- For External Hazards:
  - I. Time
  - II. Distance
  - III. Shielding



Reduce Time



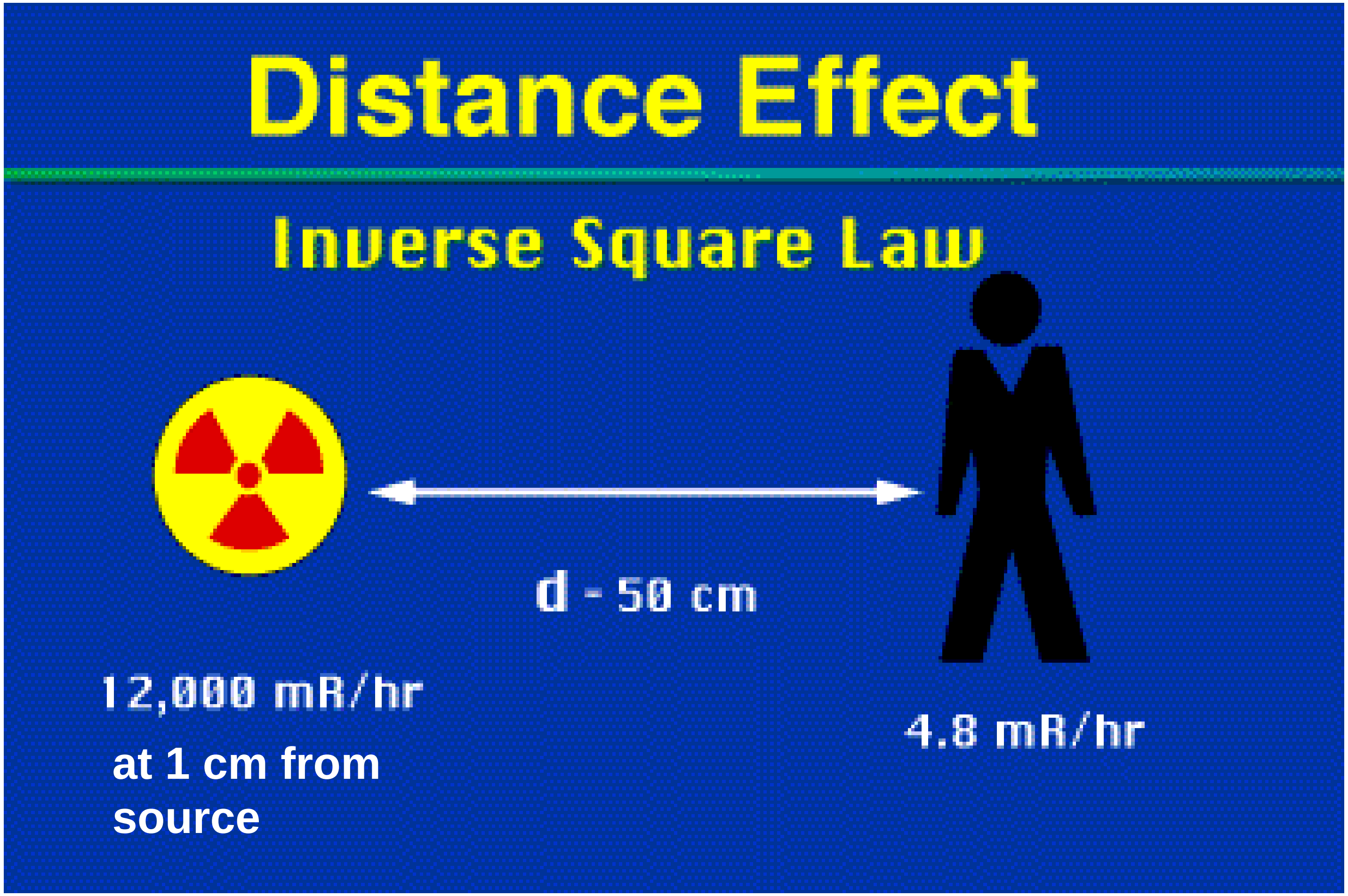
Time Relationship
Exposure rate = 1 mR/hr
x
Time
=
Total Exposure
1 hour = 1 mR
2 hours = 2 mR



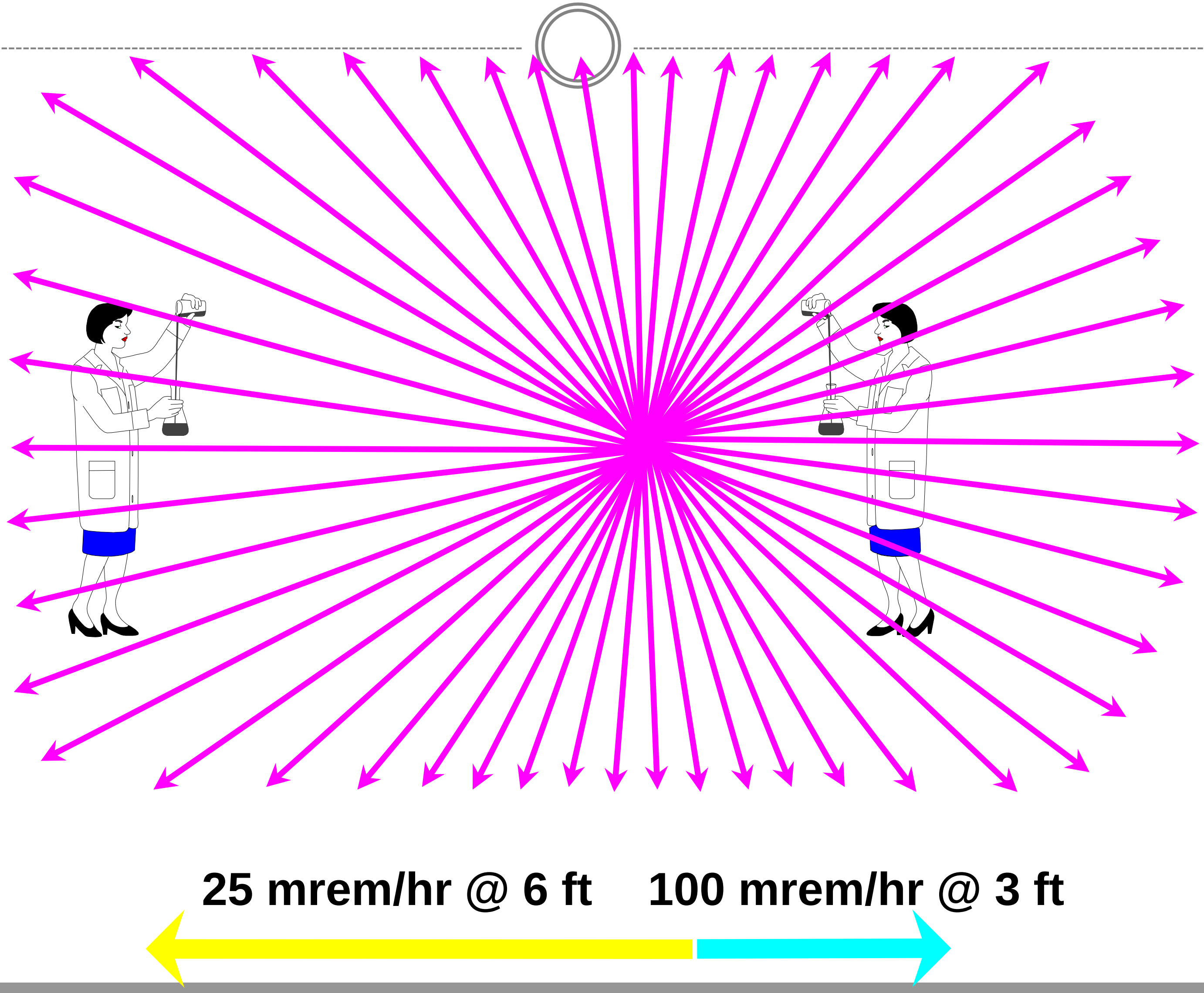
Time

- Less time = Less radiation exposure
- Use Radioactive Material only when necessary
- Dry runs (without radioactive material)
- Shorten time when near Radioactive Material
- Obtaining higher doses in order to get an experiment done quicker is NOT “reasonable”!

Increase Distance

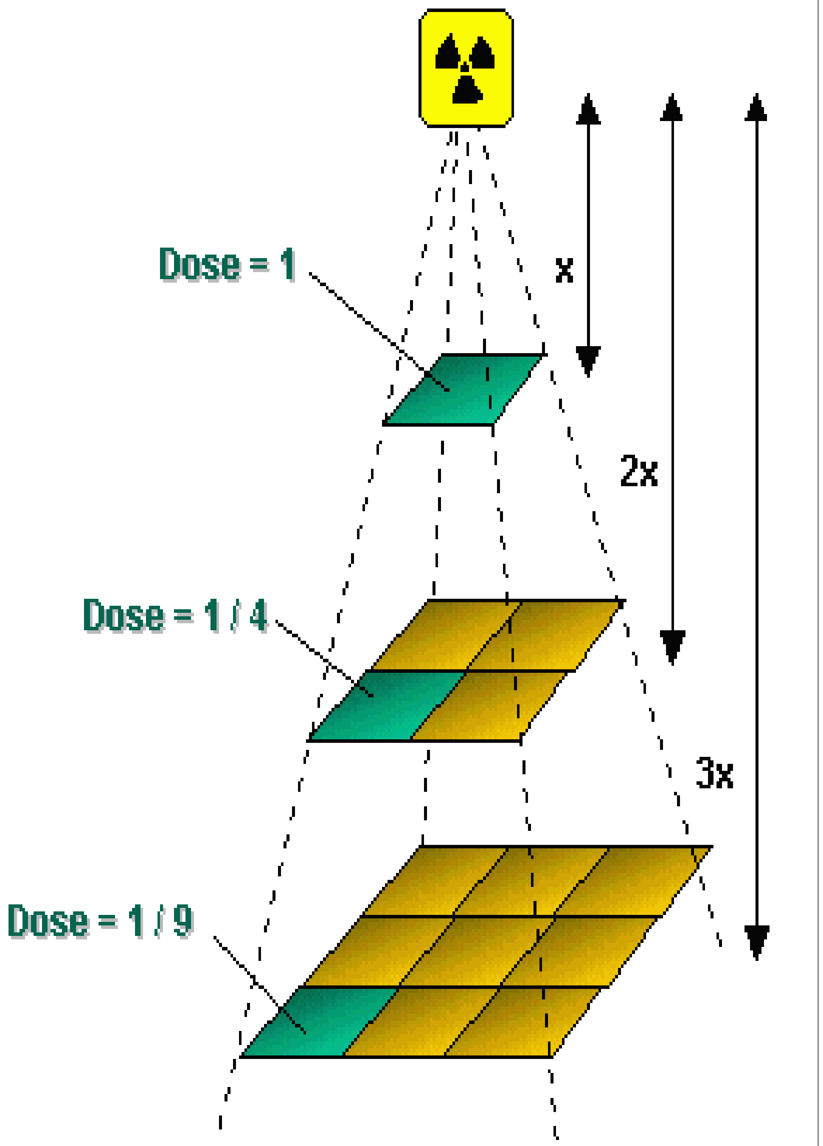


Effect of Distance on Dose Rate

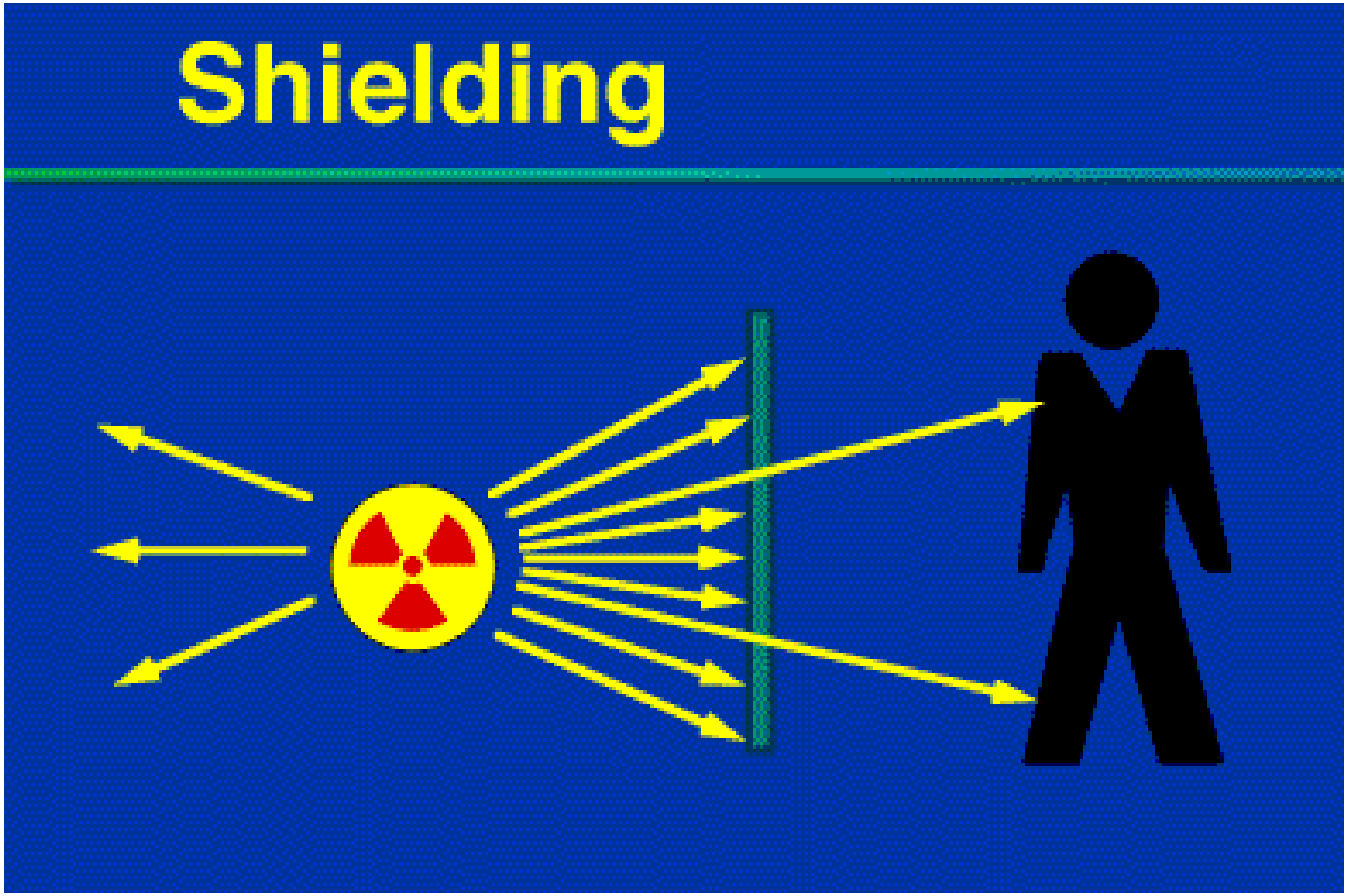


Distance

- Effective & Easy
- Inverse Square Law
  - Doubling distance from source, decreases dose by factor of four
  - Tripling it decreases dose nine-fold
- More Distance = Less Radiation Exposure
- Tongs, Tweezers, Pipettes, Pliers

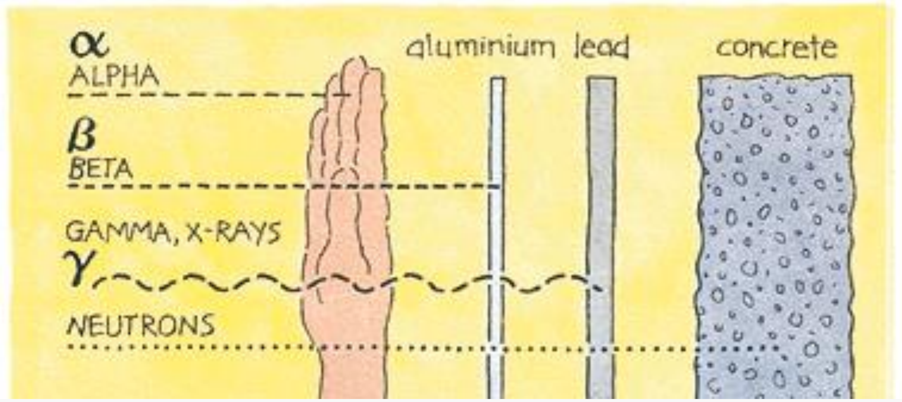


Use Shielding



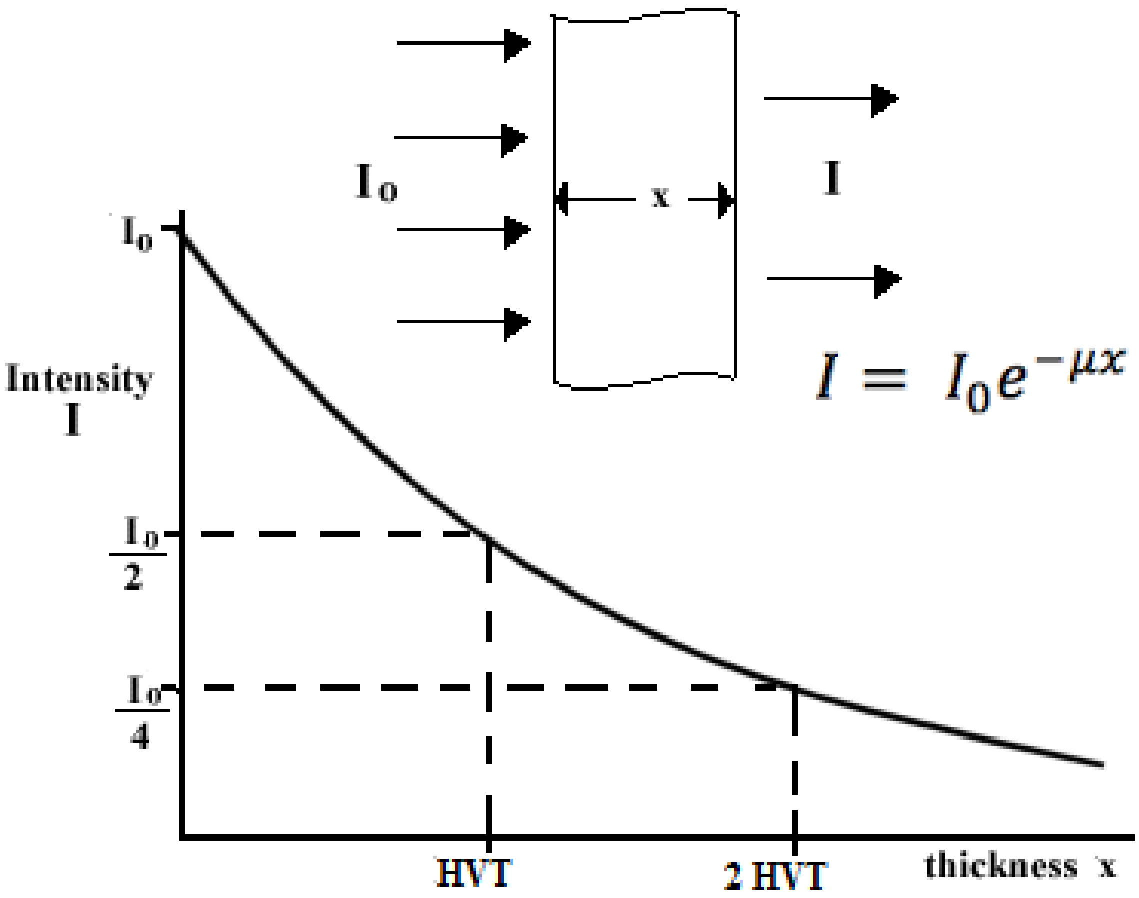
Shielding

- Alpha Emitters (^{238}U, ^{230}Th, ^{241}Am, ^{222}Rn)
  - Paper
- Low Energy Beta Emitters (^{3}H, ^{14}C, ^{35}S, ^{33}P)
  - Paper



- Medium / High Energy Beta Emitters (^{32}P)
  - Plastic
- X-ray & γ-ray Emitters (^{60}Co, ^{137}Cs, ^{192}I, ^{125}I)
  - Lead, concrete, steel, etc.
- Neutron Sources (Accelerators, Reactors, Am/Be)
  - Water, plastic, paraffin, etc.

Shielding of X-ray/γ-ray



Half value & Tenth value thickness (HVT & TVT)

HVT- It is that thickness of the shielding material which will reduce the radiation intensity to half of the original intensity

TVT- It is that thickness of the shielding material which will reduce the radiation intensity to one tenth of the original intensity

TVT = 3.3 x HVT

Reduction Factor

1 HVT of a shielding material provide a reduction factor of 2

2 HVT produces a reduction factor of 2 x 2 or $2^2 = 4$

The reduction factor offered by **n** number of HVT of shielding material is 2^n

1 TVT of a shielding material provide a reduction factor of 10

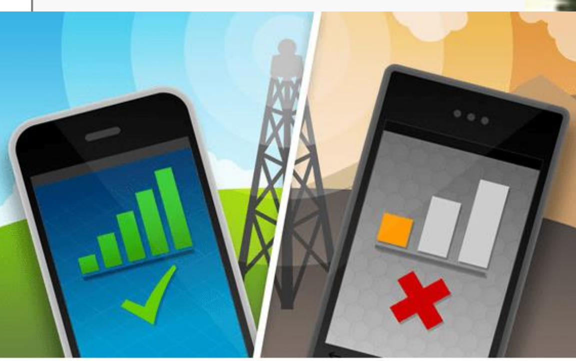
2 TVT produces a reduction factor of 10 x 10 or $10^2 = 100$

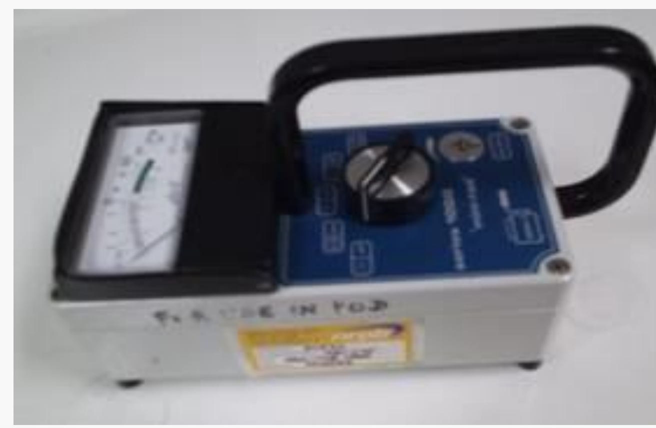
The reduction factor offered by **n** number of TVT of shielding material is 10^n

HVT & TVT Values

Radio-isotope	Concrete (cm)		Steel (cm)		Lead (cm)		Depleted Uranium (cm)	
	HVT	TVT	HVT	TVT	HVT	TVT	HVT	TVT
^{192}Ir	4.6	14	1.25	4.0	0.48	1.6	0.31	1.0
^{137}Cs	4.8	15.7	1.5	5.2	0.7	2.2	0.4	1.3
^{60}Co	6.6	21.8	2.0	6.6	1.2	4.0	0.7	2.2

Radiation Monitoring Instruments





Regulation of Radiotherapy Facilities in India

Why Regulation ?

RISK ↑		
	NOT ALLOWED	REGULATED
	NOT ENCOURAGED	HIGHLY ENCOURAGED

BENEFIT →

What is Regulation ?

- Regulation refers to "controlling human or societal behavior by rules or restrictions"
- Costs for some and benefits for others
- Efficient where the total benefits to some people exceed the total costs to others
- Regulatory agencies deal in regulation
  or rulemaking and
  enforcing rules and regulations for the benefit of the public at large

System of Regulatory Control

Issued by Central Government

- Act

(Atomic Energy Act, 1962)

- Rules

(Atomic Energy Radiation Protection) Rules, 2004)

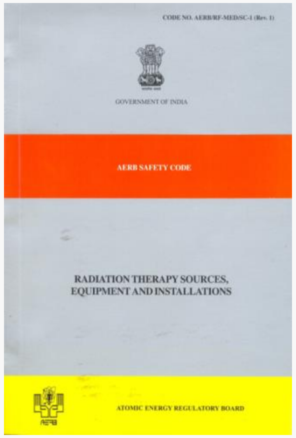
- Notifications

(Radiation Surveillance Procedures for Medical Applications of Radiation, 1989)

Published by AERB

- Safety Code

AERB/RF-MED/SC-1 (Rev.1)



- Safety Standards
- Safety Guides
- Safety Manuals

ATOMIC ENERGY COMMISSION

ATOMIC ENERGY REGULATORY BOARD

DEPARTMENT OF ATOMIC ENERGY

R&D CENTRES

Bhabha Atomic Research

INDUSTRIAL ORGANISATIONS

Heavy Water Board,

PUBLIC SEC UNDERT

Nuclea

SERVICE RGANISATIONS

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Mathematics

INS

Saha Institute of Nuclear Physics, Kolkata

Ahmedabad

Atomic Energy Education Society, Mumbai

The mission of AERB is to ensure that the use of ionizing radiation and nuclear energy in India does not cause unacceptable impact on the health of workers and the members of the public and on the environment.

Responsibility of Safety ?

Though AERB oversee Safety in use of Radiation Sources in the country,

the Prime Responsibility of ensuring Radiation Safety in the facility lies with the Licensee

Radiation Safety

Total Radiation Safety is achieved by

Built-in Safety

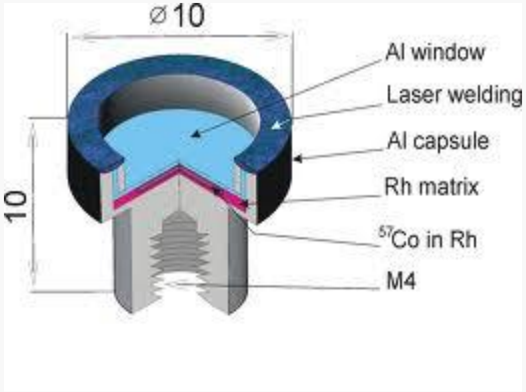
combined with

Operational Safety

Built-in Radiation Safety

- Sealed Source – Classification

  (safety of worker and public)



- Equipment – Type-approval

  Electrical, Mechanical, Radiological

  (safety of rad. worker and patient)

Built-in Radiation Safety

- Installation – Plan Approval
  Thick concrete walls, maze
  (safety of rad. worker, public and patients' relatives)

- Transport Package – Package approval
  (safety of worker, public)

Operational Safety

Components of operational safety

- Qualified and certified persons
- Work place monitoring
- Personnel monitoring
- Safe and secure storage place
- Desirable equipment for safety, dosimetry, QA
- Preventive Maintenance
- Interaction with regulatory body
- Emergency planning and preparedness

Operational Safety- Manpower, PMS

- Adequate No. of Qualified and certified persons

  (Radiation Oncologist, Medical Physicist, Radiation Therapy Technologist)

- Personnel monitoring

  (TLD for all radiation worker)

Operational Safety – Monitoring, Maintenance

- Work place monitoring

(Gamma Zone Monitor)

(Switches, Interlocks, Indicators)

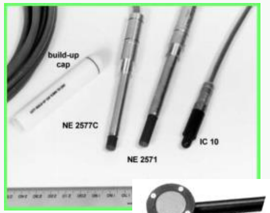
- Preventive maintenance

Operational Safety – Survey, Dosimetry

- Appropriate Monitoring equipment (survey meter, contamination monitor, gamma zone monitor[auto/manual] etc.)



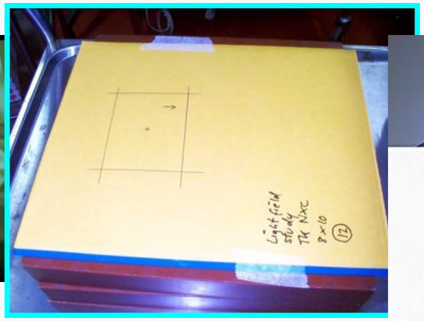
- Appropriate Measuring equipment (RFA, SSD with thimble /parallel plate/well type chamber etc.)





Operational Safety – QA & others

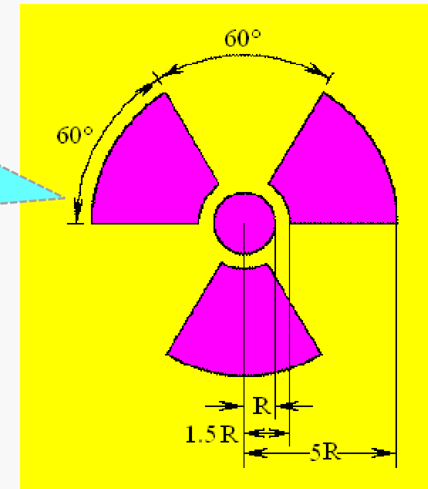
- *TPS*
- *Simulator*
- *CT-Simulator*
- *Beam modifiers*
- *Moulds*
- *QA test tools*



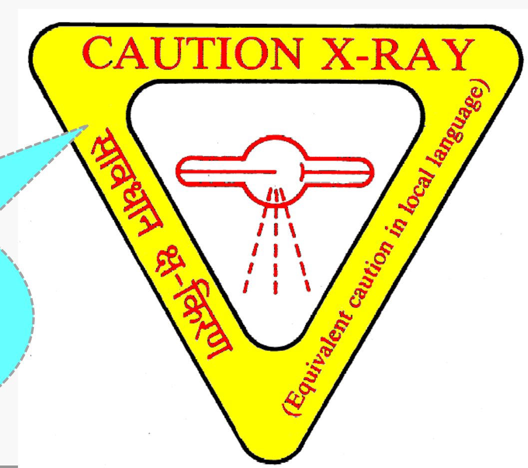
Radiation Symbol

- Radiation symbol to be posted at
  - Entrance of treatment room
  - Entrance of the controlled and supervised areas
- A legend in Hindi, English and Local language indicating radiation hazard

For Telegamma/ Brachytherapy facility

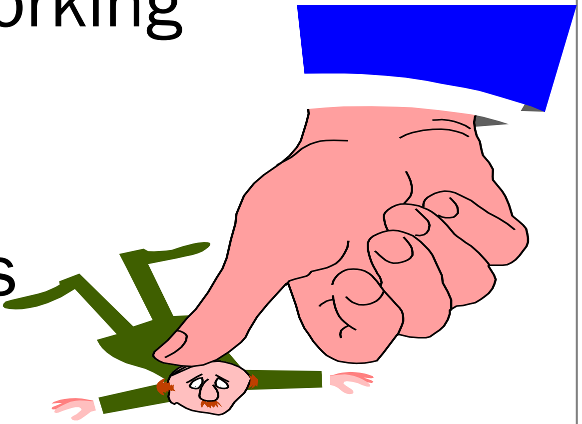


For Linac/Simulator facility



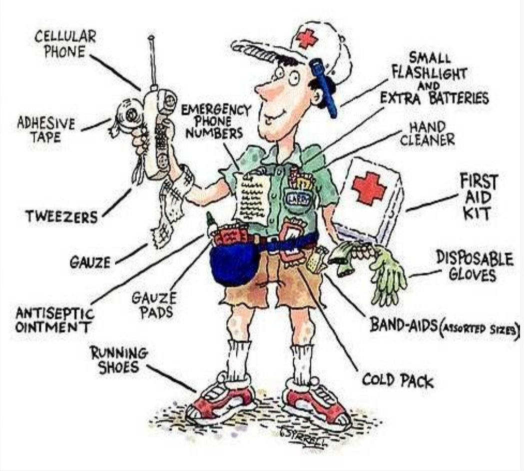
Control measures adopted in India

- **Pre-licensing stage**
  - Design Approval of Room layout
  - Approval for procurement of source
  - Commissioning approval
  - Licence for operation
- **During the useful life**
  - Information for any change in working condition
  - Radiation safety report
  - Reporting incidents or accidents
- **Post use**
  - Approval for Decommissioning/Disposal



Preparation of Emergency Preparedness Plan

- Foreseeable emergencies, include
  - Radioactive source failing to return to the safe shielding position
  - Dislodge/loss/theft of radioactive source during use, storage, transport, loss of shielding
  - Natural calamities such as fire, flood, or earthquake
  - Death of patient, with sources *in situ*
  - Selection of wrong treatment mode
  - Selection of wrong beam modifiers and wrong dose delivery.



Emergency Handling and Reporting

- Display of Emergency Procedures
- Ensure that all workers are familiar with the emergency action plan
- Release of dead body containing sources, after removal and monitoring by RSO
- Report to licensee/employer immediately and to the competent authority within 24 hours
- Lodge written complaint with police in case of loss or theft of radioactive sources, if not traced within 24 hours.

Reporting of emergency/unusual occurrences/accidental medical exposures

- Investigation report on emergency to be submitted to AERB which includes

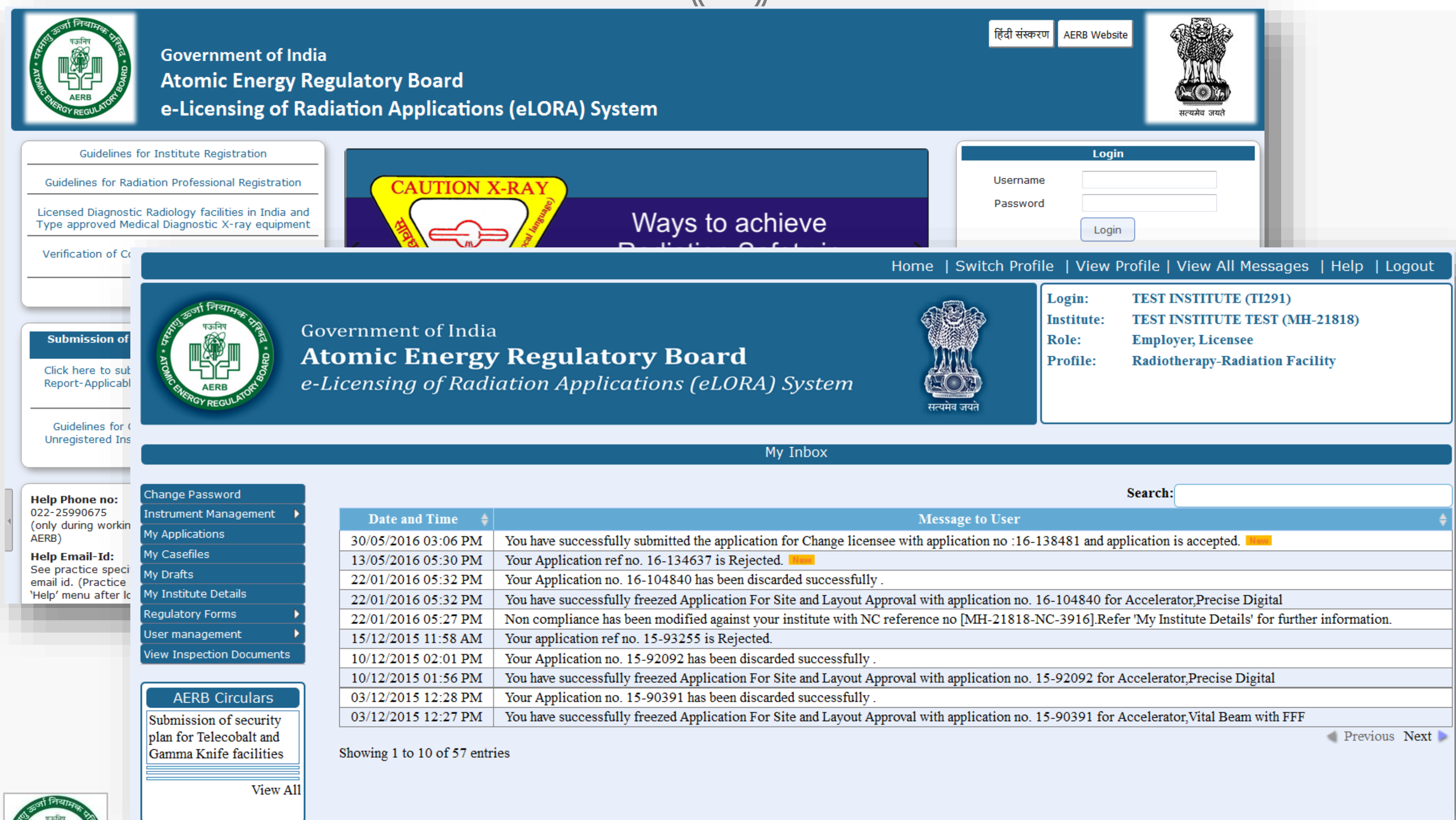
  (i) any equipment failure, accident, mishap, miscalculation or other unusual occurrence with the potential for causing a patient dose significantly different from that intended, and

  (ii) any therapeutic treatment delivered to either the wrong patient, or the wrong tissue, or using wrong source, or with a dose or dose fractionation differing substantially from the value prescribed by the radiation oncologist, or that may lead to undue acute secondary effects.

Security Plan in case of Radioactive Sources

- Security Plan is required to be prepared for radioactive sources
- Security plan for Telecobalt and Gamma Knife units need to be registered with local law enforcement agency

e-Licensing of Radiation Applications (eLORA)



Stages in eLORA for Radiotherapy

- Institute Registration
- Obtaining Layout Plan Approval
- Radiation Professional Registration(RO/MP/RTT)/their tagging/availability of Personnel Monitoring Badges
- Declaring availability of survey, dosimetry and QA equipment
- Obtaining RSO Approval
- Obtaining Equipment Procurement Permission/Intimation of Receipt
- Obtaining Source Procurement Permission/Intimation of Receipt
- Obtaining Commissioning Approval
- Submission of Survey Report and its clearance
- Obtaining License for operation
- Submission of periodic Safety Status Report
- Obtaining permission for Disposal/Decommissioning

THANK YOU

Any container bearing this symbol probably houses a radioactive material