RADIATION PROTECTION IN DIAGNOSTIC RADIOLOGY

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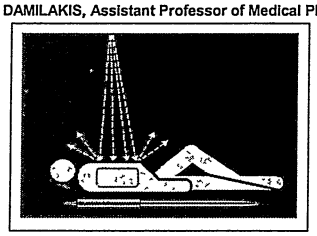
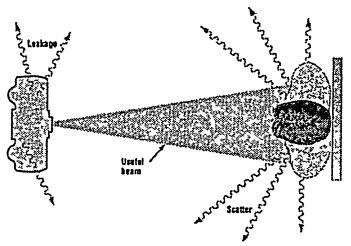
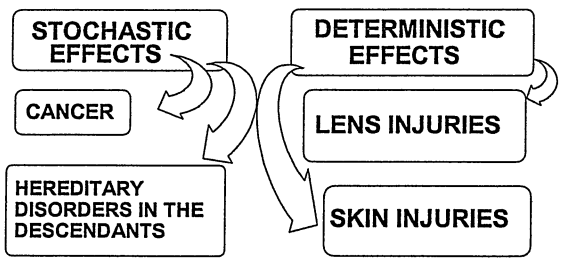


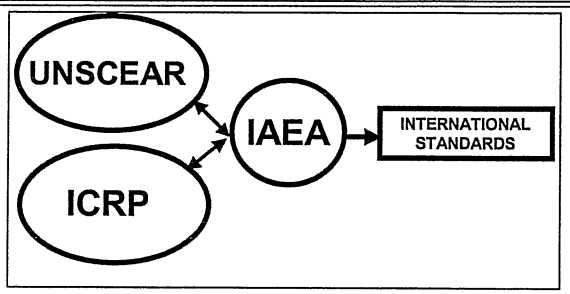


Biological effects of ionizing radiation: aims of radiation protection

- Deterministic effects
  - RP aims at PREVENTING them.
- Stochastic effects
  - RP aims at REDUCING them.



- *Radiation Protection* (RP) is a tool for the management of measures to protect health against the risks (for people and environment) generated by the use of ionizing radiation
- *Detriment:* The total harm that would eventually be experienced by an exposed group and its descendents as a result of the group's exposure to radiation from a source
- Always consider BENEFITS Vs RISKS



Relevant organizations in radiation protection

- ICRP provides recommendations
- IAEA establishes standards of safety and provides for the application of the standards
- UNSCEAR studies the effects of atomic radiation

Occupational, medical and public exposures

- Medical exposure:

  Exposure incurred by patients
  - as part of their own medical or dental diagnosis or treatment;
  - by persons, other than those occupationally exposed, knowingly while voluntarily helping in the support and comfort of patients;
  - by volunteers in a programme of biomedical research involving their exposure

System of radiation protection

- Justification of practices
- Limitation of doses
- Optimization of protection





Justification of a practice

- Justification means that any exposure produces sufficient benefit to offset the radiation harm that it might cause.
- Thus, if the exposure has not any benefit it is *not justified*.



Limitation of doses

- The normal exposure of individuals shall be restricted so that neither the total effective dose nor the total equivalent dose to relevant organs or tissues, caused by the possible combination of exposures from authorized practices, exceeds any relevant dose limit, except in special circumstances
- Dose limits shall not apply to medical exposures from authorized practices.

Dose limits (occupational exposure)

- The occupational exposure of any worker should be controlled so that the following limits be not exceeded:

Application	Occupational dose limit
Effective dose	20 mSv per year, averaged over defined periods of 5 years 50 mSv in any single year
Annual equivalent dose in:	
The lens of the eye	150 mSv
The skin	500 mSv
The hands and feet	500 mSv

Dose limits (students)

- For students of age 16 to 18 who are required to use sources in the course of their studies, the occupational exposure should be so controlled that the following limits be not exceeded:
  - **(a)** an effective dose of **6 mSv in a year**;
  - **(b)** an equivalent dose to the lens of the eye of **50 mSv in a year**; and
  - **(c)** an equivalent dose to the extremities or the skin of **150 mSv in a year.**

Pregnant workers

- A female worker should, in becoming aware that she is pregnant, notify the employer in order that her working conditions may be modified if necessary.

The occupational exposure of women

- The notification of pregnancy shall not be considered a reason to exclude a female worker from work
- The employer of a female worker who has notified pregnancy shall adapt the working conditions in respect of 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

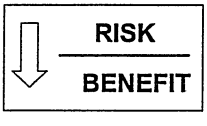
Application	**Public** dose limit
Effective dose	1 mSv in a year (*)
Annual equivalent dose in:	
The lens of the eye	15 mSv
The skin	50 mSv

(*) In special circumstances, an effective dose of up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year.

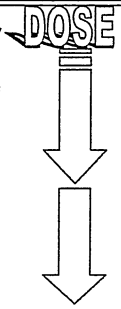
Optimization of protection

- **Optimization includes the ALARA criterion: doses should be "as low as reasonably achievable", economic and social factors being taken into account"**
- **Optimization means that minimum risk and maximum benefits should be achieved, economic and social factors being taken into account.**





- ALARA (As Low As Reasonably Achievable) refers to the continual application of the optimization principle in the day-to-day practice.





Optimization

- **Optimization of Protection does not necessarily mean the reduction of doses to patients; priority has to be given to the acquisition of reliable diagnostic information.**

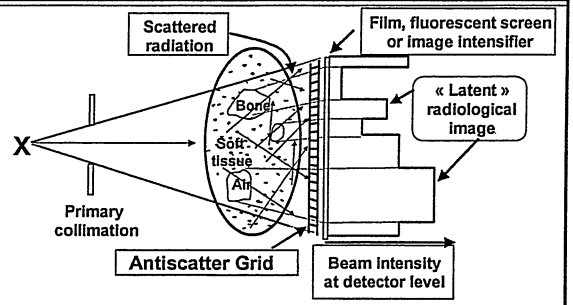
X–Ray Systems - Safe Design

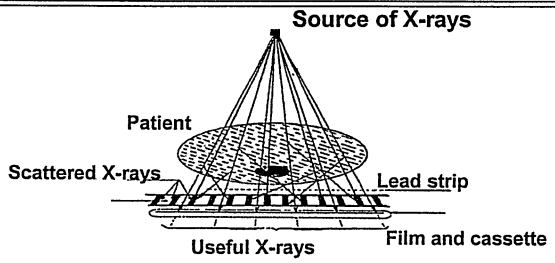
- The **failure** of a single component of the x-ray system should be readily **detectable** to avoid unplanned exposure of patients or staff
- The incidence of **human error** in the delivery of unplanned medical exposure should be minimized.

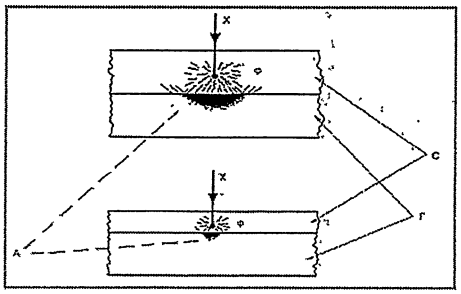
X–Ray Systems - Safe Design

Management shall:-

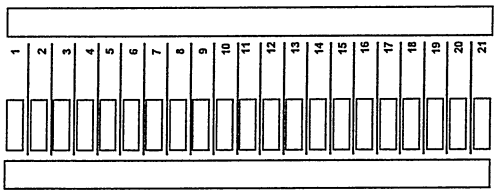
- take into account information provided by Manufacturers
- take all reasonable measures to prevent failures and errors, including the **selection of suitably qualified personnel, QA** and operation of equipment and the provision of appropriate **training and periodic retraining** to personnel in the procedures, including protection and safety aspects;
- develop appropriate **contingency plans** for responding to events that may occur (for example with x-ray systems used in interventional radiology) display plans prominently, and periodically conduct practice drills.



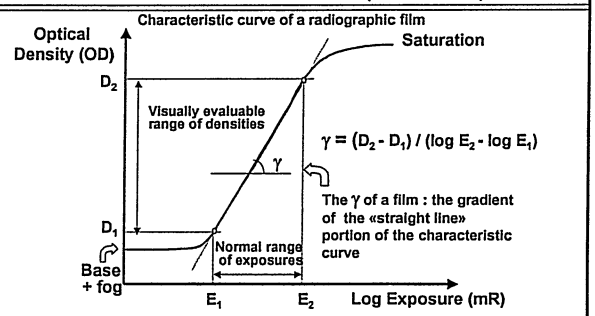


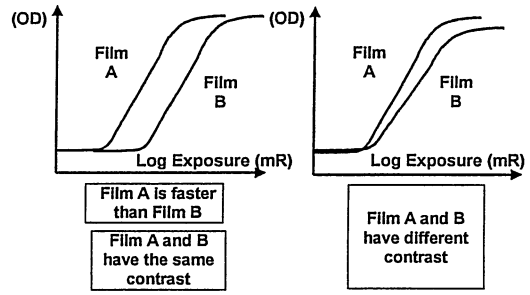


Sensitometry: A method of exposing a film by means of a light sensitometer and assessing its response to exposure and development



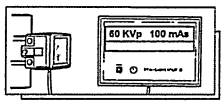






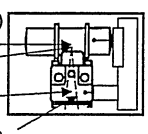
X–Ray Systems - Safe Design

Minimum parameters



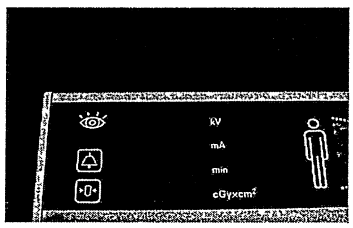
Shall Display on the control:

- Tube potential (kV peak)
- Tube current (mA)
- Exposure time (s)
- Tube current – time product (mAs)



Shall display on the tube or on the Collimator

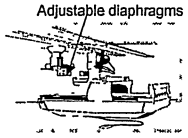
- Filtration
- Focal Spot
- Field size
- Source to image receptor distance



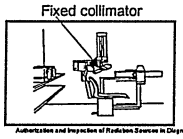
X–Ray Systems - Safe Design

The systems shall have a **collimator** to restrict the radiation field size to the area of clinical interest.

Radiographic
Adjustable diaphragms

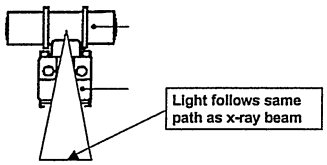


Dental :
Fixed collimator



X–Ray Systems - Safe Design

Radiographic and Mammographic systems (except for dental) shall have a light beam to indicate the position and extent of the radiation beam, visible during normal lighting conditions.

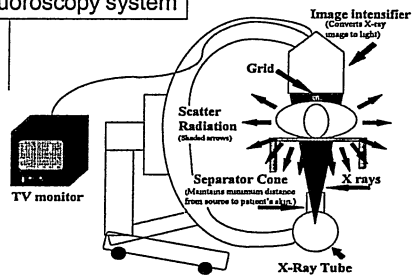


X–Ray Systems - Safe Design

Mobile or Portable X-Ray Systems :

- shall only be used for examinations where it is impractical or not medically acceptable to transfer patients to the Department of Radiology ; e.g., in the wards and operating rooms, and only after proper attention is given to radiation protection measures:
- are not designed to take the place of specially designed rooms.

Fluoroscopy system



Different fluoroscopy systems

- **Remote control systems**
  - Not requiring the presence of medical specialists inside the X-ray room
- **Mobile C-arms**
  - Mostly used in surgical theatres.





Different fluoroscopy systems

- **Interventional radiology systems**
  - Requiring specific safety considerations.
    Interventionalists can be near the patient during the procedure.



- **Multipurpose fluoroscopy systems**
  - They can be used as a remote control system or as a system to perform simple interventional procedures



X–Ray Systems - Safe Design

Fluoroscopic Systems Shall:-

- **use an image intensifier**
- have indication at the control console the instantaneous values of tube voltage (kV peak), tube current (mA) and **accumulated fluoroscopic exposure time**
- during interventional radiology (where the accumulated patient dose may be high) incorporate a **continuous indication of patient dose** such as a dose-area product meter.

X–Ray Systems - Safe Design

Digital Radiology Systems shall be provided with :

- high resolution monitors
- computers/networks
- processing software radiological information system (RIS)
- picture archiving and communication system (PACS) and
- connectivity capabilities to the hospital information system (HIS).