Personnel Radiation Protection
Personnel Monitoring
Potentially Pregnant Patients
Occupationally Exposed Women

Bushong, Chapters 35 - 38

Protection

- Basis for protection: to PREVENT detrimental stochastic or non-stochastic effects
- Stochastic:
  - Probability
- Non-stochastic (deterministic):
  - Severity

Supervisor's Responsibility

- Abide by ALARA
- Ensure no individual receives more than **5 rems (50 mSv)** in one calendar year

Operator Exposure

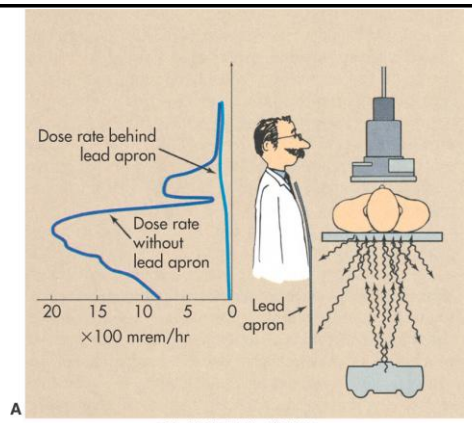
- Operator exposure is primarily due to scatter radiation from the patient
  - To a lesser degree from other scattering media (collimator, tabletop, etc) and leakage
  - Exposed only when dead-man switch is activated
  - Scatter to operator **DIRECTLY** proportional to the dose to the patient

Operator Exposure (cont)

- Operator should stand as far as practical from radiation sources
- Those who remain in the room MUST wear a protective apron of not less than 0.25 mm Pb equivalent
- Operator to wear monitoring device outside of the apron at the collar
- If so equipped, ensure bucky slot cover and protective curtains are in place

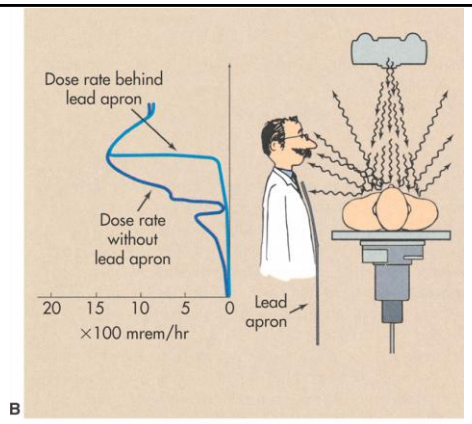
Operator Exposure (cont)

- For an under-table fluoroscopy tube, maximum intensities are at angles of 135 and 120 from the primary beam
- Minimum intensities are received at scatter angles of 45 , 60 , and 90 , in that order
- The operator always stands at right angles to the patient



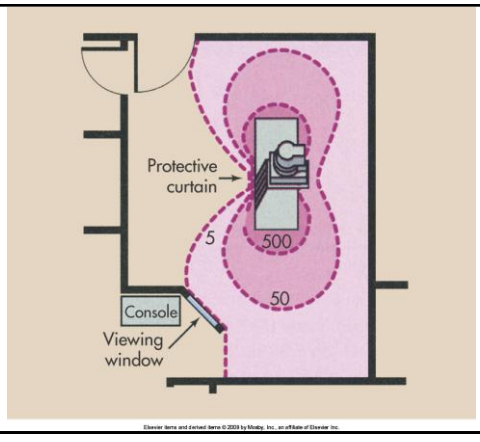
Operator Exposure (cont)

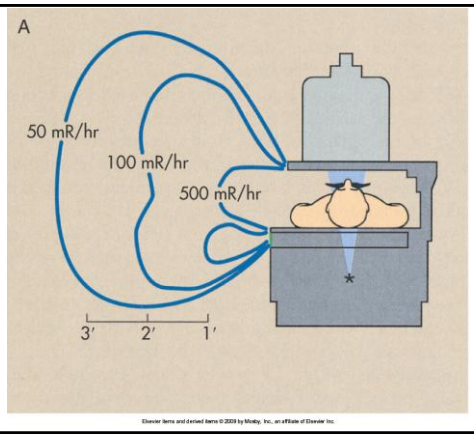
- Scatter radiation from a C-arm is highest when the x-ray tube is **above** the patient
- Operator is also exposed to leakage radiation
- Operators in interventional labs often have higher exposures because of the lack of a protective curtain and longer beam-on times

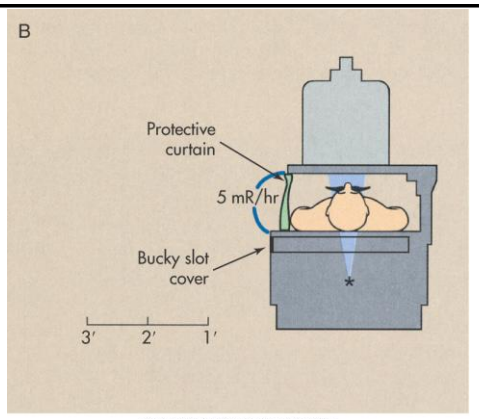


Isoexposure Contours

- Shows areas where one would receive the least amount of scatter radiation (if that person must remain in the room)
- At 1 foot from the table, the operator could receive 500 mR / hour (5 mGy/hr)
- At normal position for the operator, exposure rate is about 300 mR/hr (3 mGy/hr)







Protective Aprons

- Thickness of protective aprons <u>should</u> be 0.5 mm Pb
- **<u>SHALL</u>** be no less than 0.25 mm Pb
- Exposure lessened by 97% if using 0.25 mm Pb, 99.7% if using 0.5 mm Pb
- Covers about 80% of active bone marrow

Other Protective Devices

- Overhanging curtains (ceiling suspended), mobile screens, protective curtains (overlapping protective drapes), protective gloves, leaded glasses
- All will be <u>at least 0.25 mm Pb</u> equivalent

Personnel Monitoring Equipment

- Personnel monitoring equipment means devices designed to be worn or carried by an individual for the purpose of measuring the dose equivalent received by that individual.
- Cardinal Principles of Radiation Protection
  - Time, Distance, Shielding

Personnel Monitoring

- Records exposure in mrem
- Measures exposure over time (quantity)
- Provides an indication of the type of incident radiation (quality)
- Provides a legally acceptable record of personnel exposure
- References whole body exposure

Acceptable Legal Devices

- Film Badges
- Thermoluminescent dosimeters (TLD)
- Optically-stimulated luminescent (OSL)

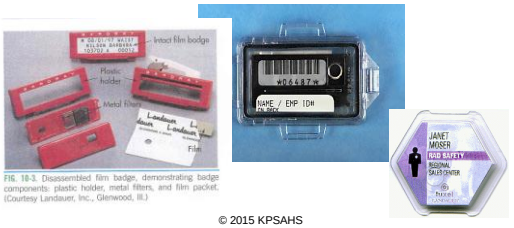
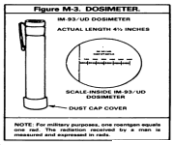


FIG. 10-3. Disassembled film badge, demonstrating badge components: plastic holder, metal filters, and film packet. (Courtesy Landauer, Inc., Glenwood, Ill.)

Accessory Devices

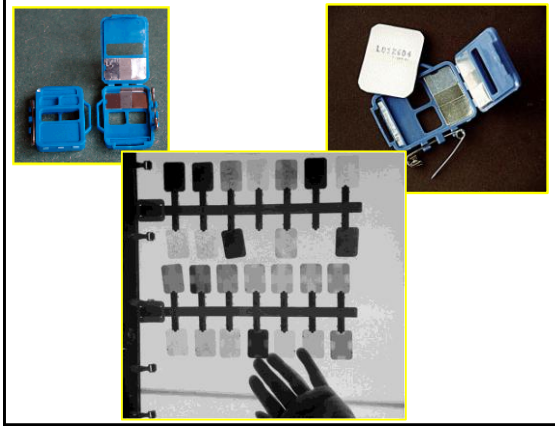
- Pocket dosimeters
- Audible Warning devices
- If an accessory device is used, it MUST be used <u>with</u> a legally acceptable device



http://www.healthcare.philips.com/main/products/solutions/doseaware/

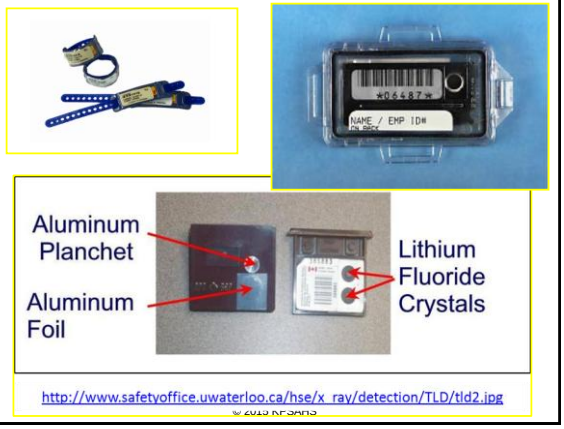
Film Badges

- Film holder
- Copper or Aluminum filters
- Packaged film
- Exposure sensitivity 10 mR - 700 R
- Accuracy 25%
- True permanent record



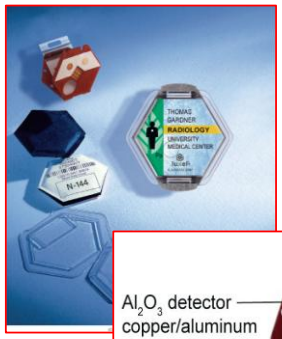
Thermoluminescent dosimeters (TLD)

- Lithium fluoride crystals
- Heated to release light
- Light released is in proportion to dose received
- Accuracy of 9%
- Initial high cost but reusable
- No true permanent record
- Accuracy as low as 5 mR

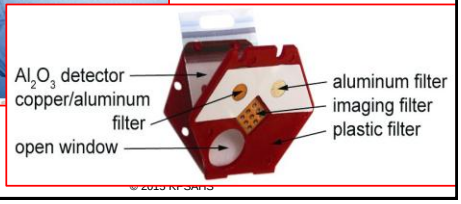


OSL

- Filters of copper and tin and an open window
  - Demonstrate energy of exposure
  - Also demonstrate if exposure occurred while static or in motion
- Issued on monthly or quarterly basis
- Sensitive to 1 mR
- Environmentally stable and durable



OSL Dosimeter



Badge Location

- Waist or chest level without apron
- At collar of apron during fluoroscopy
- Dual badges may be worn by pregnant occupational workers or those working in interventional areas

Occupational Exposure

- Means exposure that a person receives in the process of employment
- Does **not** include, background or dose individuals may receive for medical purposes
- Badge is only be worn at the place of employment
- Badge reading is presumptive evidence

Whole Body

- Head
- Trunk including gonads
- Arms above the elbows
- Legs above the knee
- EfD = 5 rem/year (0.05 Sv; 50 mSv)
  - 100 rem / Sv
- Effective Dose (E), (EfD); (DL) Dose Limit
- Limits are based on a linear, nonthreshold dose-response relationship

Other EfD (DL)

- Lens of the eye 15 rem or 0.15 Sv (150 mSv)
- Skin and / or extremities 50 rem or 0.5 Sv (500 mSv)

Non-Occupational Exposure

- Non-occupational exposed persons
- Usually hospital workers who are not radiology employees but who regularly visit the x-ray rooms
- E (or EfD or DL) is 1/10 of that established for the radiation worker

Population Dose Limits

- 0.1 rem (1 mSv) / year
  - 100 mrem
- 0.002 rem or 2 millirems in one hour (2 mrem / hour)
  - 0.02 mSv

Frequency Reporting

- Most badges typically changed out monthly, TLD's quarterly
- State advises monthly changes regardless of the type (no minimum or maximum monitoring time frame)
- Up to 1 year to report each monthly or quarterly dose

- **Practically all overexposure reports to the RHB are a result of poor practice on the part of the X-ray supervisor/operator who conducted the exam**

Monitoring Requirements

- **High Radiation Area** = 0.1 rem (1 mSv) in 1 hour at 30 cm from source
- **Radiation Area** = 0.005 rem (0.05 mSv) in 1 hour at 30 cm from source
- Persons operating mobile x-ray equipment

Area Definitions

- Restricted Area
  - A area in which access is limited by the licensee for the purpose of protecting individuals against undue risk from exposure to radiation
- Unrestricted Area
  - An area to which access is neither limited nor controlled by the licensee.

Area Definitions

- Controlled Area
  - Barrier should reduce exposure to less than 100 mrem/wk
  - Design based on a dose limit of 5000 mrem (5 rem) per year
- Uncontrolled Area
  - An area which can be occupied by anyone, where the exposure does not exceed 100 mR/yr, or 2 mR/wk
  - The barrier to limit exposure to less than 2 mR/hr

Area Definitions

- Radiation Area
  - A area accessible to individuals, in which they could receive in excess of **0.005 rem (0.05 Sv)** in 1 hour at 30 cm from the source
- High Radiation Area
  - An area accessible to individuals, in which levels could result in an individual receiving a dose equivalent in excess of **0.1 Rem (1 mSv)** in 1 hour at 30 cm from the source

Very High Radiation Area

- An area accessible to individuals in which radiation levels could be in excess of **500 rads (5 Gy)** in 1 hour at 1 meter from the source.

Potentially Pregnant Patients

Women of Childbearing Age

- Small potential for adverse biological effects
- There is no threshold dose
- Effects are directly proportional to absorbed radiation dose (linear, non-threshold)

Recommendation to Women of Childbearing Age

- Since there is no absolutely “safe” period for the conduct of diagnostic x-ray examination, should women who have a potential to be pregnant and women having abdominal area x-rays be scheduled according to their menstrual period or postponed to reduce the possibility of exposing an unsuspected embryo/fetus to radiation?

Recommendation to Women of Childbearing Age (cont)

- The answer is “no”
- Exams falling into this category need not be postponed or selectively scheduled unless it may be related to the patient’s current illness

Occupationally Exposed Women

Occupationally Exposed Women

- Must declare in writing conception dates
- Dose not to exceed 0.5 rem (5 mSv) for the gestational period
- At declaration if the fetal dose is found to be 0.5 rem (5 mSv) (0.05 rem or 0.5 mSv), then the dosage remaining for the rest of the pregnancy can not exceed 0.05 rem or 0.5 mSv

Occupationally Exposed Women

- Not to exceed 0.05 rem or 50 mrem in any one month.
- Risk during 1st Trimester
- Due to ALARA, the employer does NOT have to reassign
- Delay having children
- Take leave of absence if a realistic option

Occupationally Exposed Women

- No patient holding
- Wrap around apron
- Dual monitoring badges
  - If a “baby badge” is worn, it is worn at the waist UNDER the apron during portables or fluoroscopy