

**READING HOSPITAL SCHOOL OF HEALTH SCIENCES  
MEDICAL IMAGING PROGRAM  
RADIATION PROTECTION—2021**

**RADIATION MONITORING**

**I. Requirements**

- a. Required when there is a likelihood that an individual will receive more than \_\_\_\_\_ (~12.5 mSv) the recommended annual dose of 50 mSv
- b. To keep with ALARA concept most facilities issue devices when personnel might receive \_\_\_\_\_% of that dose

**II. Purpose**

- a. Provides working habits and conditions of imaging personnel
- b. Occupational exposure
- c. Measures the quantity of ionizing radiation exposure
- d. Not a method of protection

**III. Placement**

- a. Must be worn with proper side forward
- b. During diagnostic radiology, the badge should be worn at \_\_\_\_\_ level on the anterior side of the individual
- c. Consistency of wearing in proper location is up to the \_\_\_\_\_
- d. When wearing a lead apron, the badge should be worn at collar level on the \_\_\_\_\_ of the apron
- e. Second monitor with apron (high level studies)
  - Inside apron at waist level
- f. Embryo-fetus monitor
  - Inside apron at waist level
- g. Extremity dosimeter
  - When hands are required to be in the primary beam

#### **IV. Control Badge**

- a. Used to calculate monthly occupational doses
- b. Badge is kept in a distant room and the reading (which consists of background radiation) is \_\_\_\_\_ from your total reading to give you your monthly occupational dose

#### **V. ALARA Investigations**

- a. ALARA I (calendar quarter)
  - \_\_\_\_\_ mrem deep dose
    1. 1250 mrem shallow dose
    2. 375 mrem lens of the eye
    3. 1250 mrem to the limbs
  - Involves advisement from the RSO
- b. ALARA II (calendar quarter)
  - \_\_\_\_\_ mrem deep dose
    1. 3750 mrem shallow dose
    2. 1125 mrem lens of the eye
    3. 3750 mrem to the limbs
  - Member of the RSO staff will investigate reasons for high levels

#### **VI. Monitor Characteristics**

- a. Lightweight and easy to carry
- b. Durable to tolerate normal use
- c. Reliably detect exposures from small to large
- d. Not effected by outside influences
  - Weather
  - Humidity

- Mechanical shock
- e. Inexpensive to purchase and maintain
- f. Easy to maintain

## VII. Types of Personnel Monitoring

### a. Film badge

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses \_\_\_\_\_ film
- Filters low energy x-ray, gamma and beta
- Has \_\_\_\_\_ and \_\_\_\_\_ filters that allow conversion to tissue dose
- Advantages
  1. Cost efficient- A few dollars a month
  2. Provides permanent legal record
  3. Detects different types of radiation and can discriminate between types
  4. Measures as low as 0.1mGy
  5. Durable if dropped
  6. Can determine if exposure is from scatter or primary radiation
- Disadvantages
  1. Accuracy is limited to \_\_\_\_\_%
  2. Temps and humidity can cause inaccurate readings by fogging
  3. Not recommended to be used more than 1 month
  4. Not reusable
  5. Reading can take a longer time because badge has to be sent out to be read



FIGURE 5-4 Disassembled film badge, demonstrating badge components: plastic holder, metal filters, and film packet.



b. TLD- Thermoluminescent Dosimeter

- Light free device with crystalline form of \_\_\_\_\_ that functions as the sensing material
- Energy stored by trapping electrons in crystal lattice
- Crystals are heated and the stored energy is released in form of visible light which is measured by a photomultiplier tube. The light emitted is \_\_\_\_\_ proportional to the exposure.
- Advantages
  1. Not effected by humidity or normal temperature changes
  2. Measures as low as \_\_\_\_\_ mGy, exposures below that are recorded as minimal.
  3. Can be worn for \_\_\_\_\_ months
  4. Crystals can be reused after reading which can be cost efficient
- Disadvantages
  1. High initial cost and cost of equipment to do reading
  2. Readings can be lost is not carefully recorded because once energy is released from crystals it cannot be reread
  3. Records only exposure to area in which it is worn

c. OSL- Optically Stimulated Luminescent Dosimeter

- Best features of film badge and TLD
- Detector is \_\_\_\_\_
- Contains 3 filters:
  1. \_\_\_\_\_ (least absorption, shallow)



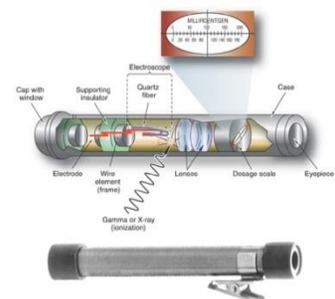
2. \_\_\_\_\_ (eye)

3. \_\_\_\_\_ (most absorption, deep)

- Electrons are trapped in badge. Read out is done when dosimeter is struck by laser light
  1. Releases energy in the form of light
  2. Luminescent is proportional to the amount of exposure received
- Exposures below \_\_\_\_\_ mGy are recorded as minimal
- Newer development is a reader called the microStar which reads a special OSL dot called a nanoDot
- Advantage
  1. Lightweight, durable and easy to carry
  2. Self-contained preloaded packet
  3. Not affected by heat, moisture or pressure
  4. Has extended wear up to one year, but recommended for a 2 month period
  5. Offers complete reanalysis
  6. Reasonably inexpensive to purchase and maintain
- Disadvantage
  1. Only record exposure to area where worn
  2. Has to be sent out to be read
    - a. So some time elapses before you receive your reading
    - b. Unless you have the nanoDot version of the OSL

d. Pocket ionization chamber

- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes



1. one positive charge
2. one negative charged

- There is a:

1. Self-reading- contains an electrometer to provide reading
2. non-self-reading type- requires an accessory electrometer

- Advantages

1. Provides immediate \_\_\_\_\_
2. Compact, easy to carry
3. Convenient

- Disadvantages

1. Fairly expensive
  - a. \$ \_\_\_\_\_ per unit
2. Inaccurate if not read daily
3. Can be discharged by a mechanical shock
4. No permanent legal record

e. Digital Ionization Dosimeter

- Fairly new device

- Provides immediate radiation exposure but can also do long term

- Looks like a \_\_\_\_\_

- Contains an ionization chamber that produces and stores electrical charge

- Connects to a computer to provide a readout

1. Activates the vendor's software for readout

- Advantages

1. Lightweight
2. Instant reports
3. Doesn't have to be mailed in

4. Isn't easily affected by being dropped or bumped

- Disadvantages

1. Not effective if not worn properly

## **VIII. Records of Personnel Monitoring**

a. Purpose is to keep an ongoing tally of employee occupational exposure

b. Results must be recorded and maintained to meet state and federal regulations

c. Records must be kept permanently

d. Should retrieve records from previous employers and present them to new employer

e. Requirements

- Timeframes

1. Period of time wearing (monthly for us),

2. Quarterly

3. Yearly

4. Lifetime

- Doses

1. Deep dose equivalent- DDE

a. 1cm depth in soft tissue

b. Absorbed dose

2. Shallow dose equivalent- SDE

a. 0.007cm depth in soft tissue

b. Skin dose

3. Eye or Lens dose equivalent- EDE or LDE

a. 0.3cm depth in the eye

b. Exposure to the lens

## IX. Terminology

### a. Committed Dose Equivalent- CDE

- Total dose equivalent received over a period of time, usually during a 50 year period from inhaled or ingested radioactive material

#### 1. Examples:

- Specific to a single organ or tissue
- \_\_\_\_\_ mSv annual dose limit to single organs

### b. Committed Effective Dose Equivalent- CEDE

- Applies to long term radiation of individual organs or tissue resulting from inhalation or ingestion of long lived radioactive material (long decay life)
- Sum of all organs (CDE) x weighting factor for importance (tissue weighting factors)
- Delivered slowly over long period of time from an inhaled or ingested material

### c. Total Effective Dose Equivalent- TEDE

- Defined by the NRC
- Sum of the deep dose equivalent for external radiation and the committed dose equivalent for internal radiation
- $DDE + CDE = TEDE$
- Annual dose limit is \_\_\_\_\_ mSv (whole body) to limit the risk cancer, genetic effects, cataracts, skin damage, sterility.....

## X. Radiation Survey Instruments

### a. Detects and measures radiation

### b. Detects the presence or absence of radiation

### c. Requirements

- Easy to carry and operated by one person

- Durable enough to withstand normal use
- Reliable
- Should interact with radiation similar to human tissue
- Should be able to detect all types of radiation
- Energy of the radiation should not affect the detector
- Should be cost effective

d. Gas Filled Survey Instruments

- Ionization chamber “cutie pie”
  1. Rate (measures the rate of exposure) and survey meter
  2. Used to measure radiation in an area such as a fluoro room, radioisotope storage area or patient with a radioactive source
  3. Can be used to measure doses traveling through a barrier
  4. Advantages
    - a. Measures a wide range of exposures in a few seconds
    - b. Can be used to calibrate x-ray equipment
  5. Disadvantages
    - a. Adequate warm up
    - b. Large size
    - c. Delicate construction
    - d. Not good with short exposure times



FIGURE 5-11 Ionization chamber-type survey meter, or “cutie pie.”

- Proportional counter
  1. No useful purpose in diagnostic radiology
  2. Used in laboratories to detect \_\_\_\_\_ and \_\_\_\_\_ radiation
  3. Detects small amounts of other contamination



FIGURE 5-12 Geiger-Müller (GM) Detector.

- Geiger Muller (G-M) detector
  1. Used mainly in \_\_\_\_\_
  2. Easily detects areas of contamination and has an audio signal
  3. Signal increases as radiation is more intense
    - a. Reads in counts per minute

## **XI. Safety Features**

- a. On and off switches- power equipment down
- b. Interlocks- detents
- c. Visual/ audio- timer and audible signals
- d. Emergency controls- breakers, stop buttons
- e. Calibrations
  - Ionization chambers used in the rate mode can be used to calibrate equipment when used with an electrometer
    1. Used by medical physicist for standard measurements required by state, federal, and accreditation organizations for x-ray and fluoro units. Examples:
      - a. X-ray output
      - b. Reproducibility and linearity of output
      - c. Timer accuracy
      - d. Half value layer
      - e. Beam quality
      - f. Entrance exposures for fluoro
      - g. With a calibrated parallel plate chamber it could check mammo equipment
  - Collimation accuracy- 2%
  - SID indication- 2%
  - PBL- 2%
  - Variation in exposure- 5%

f. Equipment surveys

- Surveys must be done by \_\_\_\_\_ and in writing
- Keep permanently and indicate if a resurvey is necessary and if so when
- Safety surveys are done in conjunction with

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- Performance surveys are done \_\_\_\_\_

- Examples

1. Timer accuracy
2. Exposure reproducibility
3. kVp test
4. Linearity of mAs
5. Tube stability
6. Beam limiting device
7. Timer
8. Primary barrier
9. kVp and mAs indication
10. High levels control
11. Exposure rate limits