



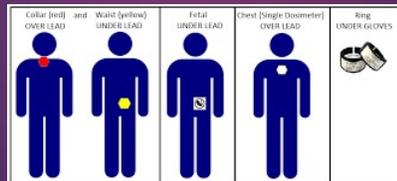
Radiation Monitoring

Mrs. Heather Herb, B.S., R.T.(R)(M)
MI Program

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Requirements

- ▶ Required when there is a likelihood that an individual will receive more than one-quarter (~12.5 mSv) the recommended annual dose of 50 mSv
- ▶ To keep with ALARA concept most facilities issue devices when personnel might receive 1% of that dose



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Purpose

- ▶ Provides working habits and conditions of imaging personnel
- ▶ Provides occupational exposure
- ▶ Measures the quantity of ionizing radiation exposure
- ▶ Not a method of protection



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Placement

- ▶ Worn with proper side forward
- ▶ During diagnostic radiology, the badge should be worn at collar level on the anterior side of the individual
- ▶ Consistency of wearing in proper location is responsibility of the technologist/ student
- ▶ When wearing a lead apron, the badge should be worn at collar level on the outside of the apron
- ▶ Second monitor with apron (high level studies)
 - ▶ Inside apron at waist level
- ▶ Embryo-fetus monitor
 - ▶ Inside apron at waist level
- ▶ Extremity dosimeter
 - ▶ When hands are required to be in the primary beam



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Control Badges

- ▶ Used in calculating monthly occupational doses
- ▶ Badge is kept in a distant room and the reading (which consists of background radiation) is subtracted from your total reading to give you your monthly occupational dose



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ALARA Investigations

- ▶ ALARA I (calendar quarter)
 - ▶ 125 mrem deep dose
 - ▶ 1250 mrem shallow dose
 - ▶ 375 mrem lens of the eye
 - ▶ 1250 mrem to the limbs
 - ▶ Involves advisement from the RSO
- ▶ ALARA II (calendar quarter)
 - ▶ 375 mrem deep dose
 - ▶ 3750 mrem shallow dose
 - ▶ 1125 mrem lens of the eye
 - ▶ 3750 mrem to the limbs
 - ▶ Member of the RSO staff will investigate reasons for high levels

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Monitor Characteristics

- ▶ Lightweight and easy to carry
- ▶ Durable to tolerate normal use
- ▶ Reliably detect exposures from small to large
- ▶ Not effected by outside influences
 - ▶ Weather
 - ▶ Humidity
 - ▶ Mechanical shock
- ▶ Inexpensive to purchase and maintain
- ▶ Easy to maintain



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Types of Personnel Monitoring

- ▶ Film Badge
- ▶ OSL
- ▶ TLD
- ▶ Pocket Ionization Chamber
- ▶ Digital Ionization Dosimeter



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Film Badge Disadvantages

- ▶ Accuracy is limited to +/- 20%
- ▶ Temps and humidity can cause inaccurate readings by fogging
- ▶ Not recommended to be used more than 1 month
- ▶ Not reusable
- ▶ Reading can take a longer time because badge has to be sent out to be read



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TLD- Thermoluminescent Dosimeter

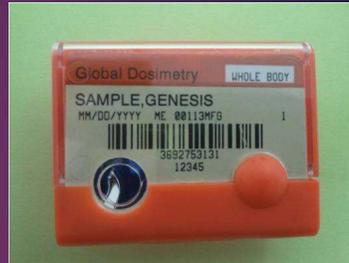
- ▶ Light free device with crystalline form of lithium fluoride that functions as the sensing material
- ▶ Energy stored by trapping electrons in crystal lattice
- ▶ Crystals are heated and the stored energy is released in form of visible light which is measured by a photomultiplier tube. The light emitted is directly proportional to exposure



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TLD Advantages

- ▶ Not effected by humidity or normal temperature changes
- ▶ Measures as low as 0.05 mGy
 - ▶ Exposures below that are recorded as minimal
- ▶ Can be worn for 3 months
- ▶ Crystals can be reused after reading which can be cost efficient



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TLD Disadvantages

- ▶ High initial cost and cost of equipment to do reading
- ▶ Readings can be lost if not carefully recorded because once energy is released from crystals it cannot be reread
- ▶ Records only exposure to area in which it is worn



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OSL- Optically Stimulated Luminescent Dosimeter

- ▶ Best features of film badge and TLD
- ▶ Detector is aluminum oxide
- ▶ Contains 3 filters: aluminum (least absorption, shallow), tin (eye) and copper (most absorption, deep)
- ▶ Electrons are trapped in the badge. Read out is done when dosimeter is struck by laser light.
 - ▶ Releases energy in a form of a light.
 - ▶ Luminescent is proportional to the amount of exposure received
- ▶ Exposures below 0.01 mGy are recorded as minimal
- ▶ Newer development is a reader called the microStar which reads a special OSL dot called a nanoDot

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OSL Advantages

- ▶ Lightweight, durable and easy to carry
- ▶ Self-contained preloaded packet
- ▶ Not affected by heat, moisture or pressure
- ▶ Has extended wear up to one year, but recommended for a 2 month period
- ▶ Offers complete reanalysis
- ▶ Reasonably inexpensive to purchase and maintain



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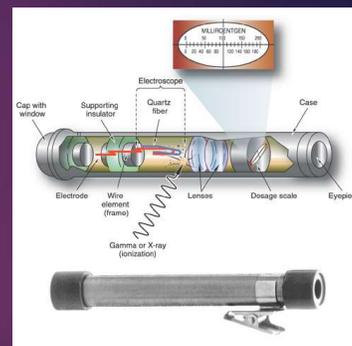
OSL Disadvantages

- ▶ Only records exposure to area where worn
- ▶ Has to be sent out to be read, so some time elapses before you receive your reading
 - ▶ Unless you have a nanoDot version of the OSL

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Pocket Ionization Chamber

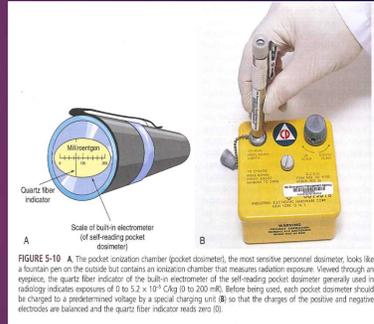
- ▶ Also known as a pocket dosimeter
- ▶ Most sensitive
- ▶ Uncommon to use in diagnostic radiology
- ▶ Resembles a fountain pen
- ▶ Contains 2 electrodes, one positive, one negative charged
- ▶ There is a:
 - ▶ self reading (contains an electrometer to provide reading)
 - ▶ non-self reading type (requires an accessory electrometer)



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Pocket Ionization Chamber Advantages

- ▶ Provides immediate readout
- ▶ Compact, easy to carry
- ▶ Convenient



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Pocket Ionization Chamber Disadvantages

- ▶ Fairly expensive
 - ▶ \$150 per unit
- ▶ Inaccurate if not read daily
- ▶ Can be discharged by a mechanical shock
- ▶ No permanent legal record



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Digital Ionization Dosimeter

- ▶ Fairly new device
- ▶ Provides immediate radiation exposure but can also do long term
- ▶ Looks like a flash drive
- ▶ Contains ionization chamber that produces and stores electrical charge
- ▶ Connects to a computer to provide a readout
 - ▶ Activates the vendor's software for reading



FIG 5.8 Personnel digital ionization dosimeter. This device is relatively small and resembles a flash drive in appearance. It provides an instant readout of dose information when connected to a computer via a connector such as a USB. (Photo courtesy of Mirion Technologies, Inc.)

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Digital Ionization Dosimeter Advantages

- ▶ Lightweight
- ▶ Instant reports
- ▶ Doesn't have to be mailed in
- ▶ Isn't easily affected by being dropped or bumped

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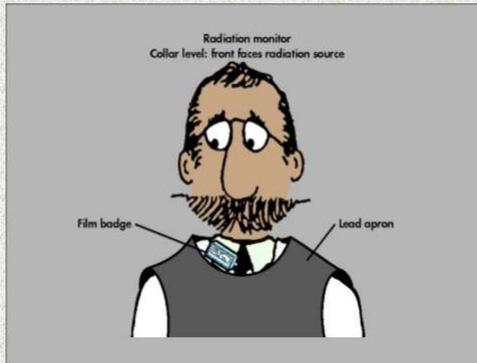
Digital Ionization Dosimeter Disadvantages

- ▶ Not effective if not worn properly

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	Instadose®2	Instadose®-R	Instadose®	APlex™	Genesis Ultra TLD™	Measuring™	Ultra™ & Flex™
Overview	All the revolutionary capabilities of Instadose™, now with measurements for radiation sources.	Revolutionary wireless capabilities enable wireless acquisition of dose responses, much, reporting.	The only available TLD compatible detector enabling digital radiation dose measurements.	After detection can be used multiple times, enabling re-evaluation into several exposures.	Like other TLD detectors, Genesis Ultra TLD offers increased signal response with virtually no fading.	Range and Report dosimeters are ideal for low or high energy beta, X-ray or gamma radiation monitoring of hands and fingers.	
Features	<ul style="list-style-type: none"> Bluetooth wireless transmission of dose reads to mobile smart devices, Instadose Manager, or Instadose™ TDS. RF cellular data distribution process. Instadose online reporting. Universal, on demand dose reads. Automatic calibration and gainable dose reads. 	<ul style="list-style-type: none"> Bluetooth wireless transmission of dose reads to mobile smart devices, Instadose Manager, or Instadose™ TDS. RF cellular data distribution process. Instadose online reporting. Universal, on demand dose reads. Automatic calibration and gainable dose reads. 	<ul style="list-style-type: none"> Universal dose reads. Electronic badge calibration and self-dose process. Instadose online reporting. Improved compliance. 	<ul style="list-style-type: none"> Permanently bonded for ease of identification and tracking. Thermal stability. Protective clear polycarbonate screen with safety window against for extreme temperature or moisture. 	<ul style="list-style-type: none"> Wear periods of 1 week to 1 year. Change read location for identification and tracking. Whole body, area monitoring. Thermal stability and fast screen re-reading. Deep shielded, low of age doses are available. 	<ul style="list-style-type: none"> Individuals calibrated. Available in 4 sizes. Can be removed in water and self-sterilizing. Clear and black plastic (10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 155, 160, 165, 170, 175, 180, 185, 190, 195, 200, 205, 210, 215, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 300, 305, 310, 315, 320, 325, 330, 335, 340, 345, 350, 355, 360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415, 420, 425, 430, 435, 440, 445, 450, 455, 460, 465, 470, 475, 480, 485, 490, 495, 500, 505, 510, 515, 520, 525, 530, 535, 540, 545, 550, 555, 560, 565, 570, 575, 580, 585, 590, 595, 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, 665, 670, 675, 680, 685, 690, 695, 700, 705, 710, 715, 720, 725, 730, 735, 740, 745, 750, 755, 760, 765, 770, 775, 780, 785, 790, 795, 800, 805, 810, 815, 820, 825, 830, 835, 840, 845, 850, 855, 860, 865, 870, 875, 880, 885, 890, 895, 900, 905, 910, 915, 920, 925, 930, 935, 940, 945, 950, 955, 960, 965, 970, 975, 980, 985, 990, 995, 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Occupational radiation monitor does NOT protect against radiation exposure!

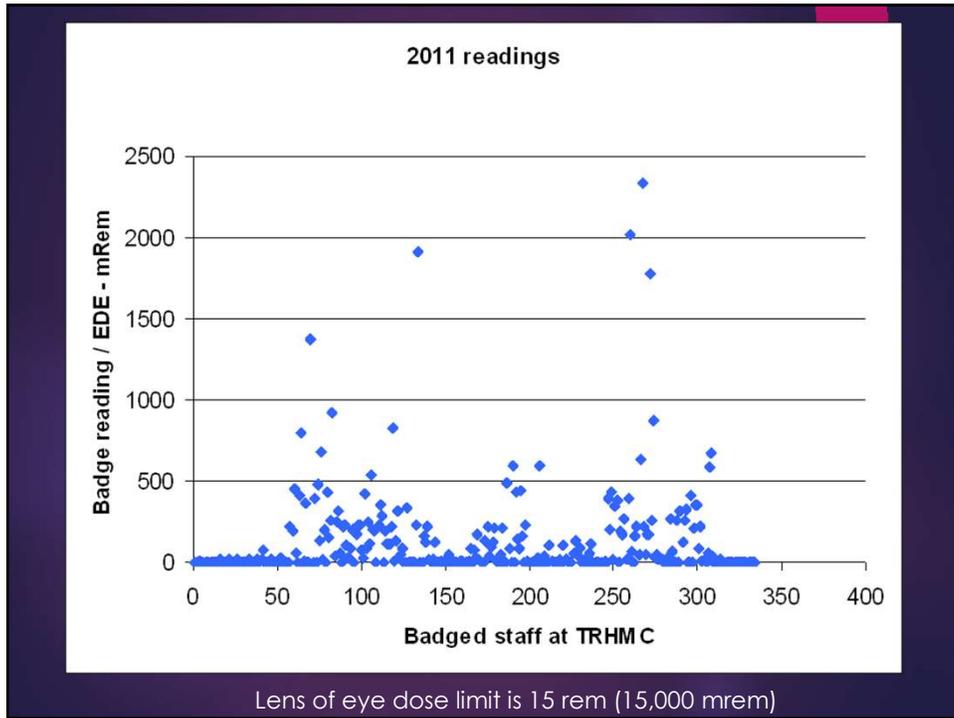


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Records of Personnel Monitoring

- ▶ Purpose is to keep an ongoing tally of employee occupational exposures
- ▶ Results must be recorded and maintained to meet state and federal regulations
- ▶ Records must be kept permanently by facilities
- ▶ Should retrieve records from previous employers and present them to new employer

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Internal Doses

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Average Diagnostic Doses for 2007

- ▶ DDE= 61.8 mrem
- ▶ LDE= 80.7 mrem
- ▶ SDE= 98.7 mrem

1000 mrem = 1 rem

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Committed Dose Equivalent

- ▶ CDE
- ▶ Total dose received over a period of time, usually during a 50 year period from an inhaled or ingested radioactive material
 - ▶ Examples; radon, contaminated food, absorption through the skin, or injected radioisotopes
- ▶ Specific to a single organ or tissue
- ▶ 500 mSv annual dose limit to single organs

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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

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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 50 mSv (whole body) to limit the risk cancer, genetic effects, cataracts, skin damage, sterility.....

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Radiation Surveys Instruments

- ▶ Detects and measures radiation
- ▶ Detects the presence or absence of radiation



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Survey Instruments 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

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Gas Filled Radiation Survey Instrument

- ▶ Ionization chamber “cutie pie”
- ▶ Proportional counter
- ▶ Geiger Muller (G-M) detector

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Ionization Chamber-Type Survey Meter “Cutie Pie”

- ▶ Rate (measures the rate of exposure) and survey meter
- ▶ Used to measure radiation in an area such as a fluoro room, radioisotope storage areas, or patient’s with radioactive sources
- ▶ Can be used to measure doses traveling through barriers

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“Cutie Pie”

- ▶ Advantages
 - ▶ Measures a wide range of exposures in a few seconds
 - ▶ Can be used to calibrate x-ray equipment
- ▶ Disadvantages
 - ▶ Adequate warm up
 - ▶ Large size
 - ▶ Delicate construction
 - ▶ Not good with short exposure times



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

Radiation Protection in Medical Radiography, 6th Ed. Statkiewicz Sherer

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Proportional Counter

- ▶ No useful purpose in diagnostic radiology
- ▶ Used in laboratories to detect alpha and beta radiation
- ▶ Detects small amounts of other types of contamination

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Geiger-Muller (G-M) Detector

- ▶ Used mainly in Nuclear Medicine
- ▶ Easily detects areas of contamination and has an audio signal
- ▶ Signal increases as radiation is more intense (similar to how a metal detector responds to metal)
 - ▶ Reads in counts per minute

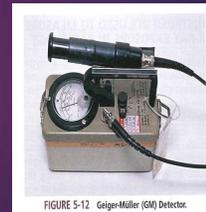


FIGURE 5-12 Geiger-Müller (GM) Detector

Radiation Protection in Medical Radiography, 6th Ed. Statkiewicz Sherer

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Safety Features in Equipment

- ▶ On and off switches
 - ▶ Power equipment down
- ▶ Interlocks
 - ▶ Detents
- ▶ Visual- audio monitors
 - ▶ Timer and audible signal
- ▶ Emergency controls
 - ▶ Breakers, stop buttons



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Calibration Instruments

- ▶ Ionization chambers used in the rate mode can be used to calibrate equipment when used with an electrometer
- ▶ Used by medical physicist for standard measurements required by state, federal, and accreditation organizations for x-ray and fluoro units.
Examples:
 - ▶ X-ray output
 - ▶ Reproducibility and linearity of output
 - ▶ Timer accuracy
 - ▶ Half value layer
 - ▶ Beam quality
 - ▶ Entrance exposures for fluoro
 - ▶ With a calibrated parallel plate chamber it could check mammo equipment
- ▶ Examples:
 - ▶ Collimation accuracy- 2%
 - ▶ SID indication- 2%
 - ▶ PBL- 2%
 - ▶ Variation in exposure- 5%



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Equipment Surveys

- ▶ Surveys must be done by RSO and in writing
- ▶ Keep permanently and indicate if a resurvey is necessary and if so when
- ▶ Safety surveys are done in conjunction with preventative maintenance
- ▶ Performance surveys are done annually

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Equipment Surveys Examples

- ▶ Timer accuracy
- ▶ Exposure reproducibility
- ▶ kVp test
- ▶ Linearity of mAs
- ▶ Tube stability
- ▶ Beam limiting device
- ▶ Timer
- ▶ Primary barrier
- ▶ kVp and mAs indication
- ▶ High levels control
- ▶ Exposure rate limits



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