Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

- Provides indication of 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

- During diagnostic radiology, the badge should be worn at collar level facing forward 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, radiation-free area 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

https://www.plmedical.com/index.php/faqs/

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MONITOR CHARACTERISTICS

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

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

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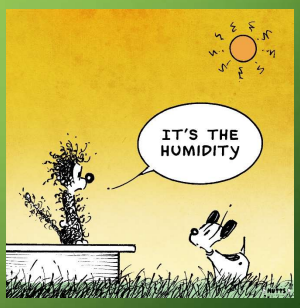
FILM BADGE DISADVANTAGES

- 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 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 is 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
- 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-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

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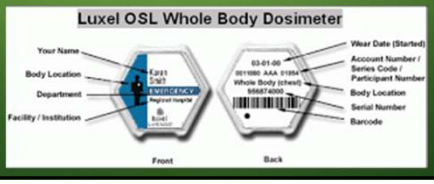
OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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 it's worn
- 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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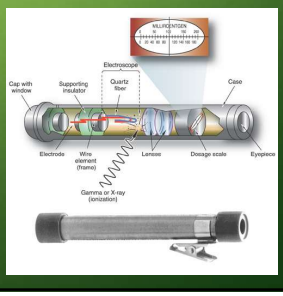
POCKET IONIZATION CHAMBER

- 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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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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DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE 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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DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

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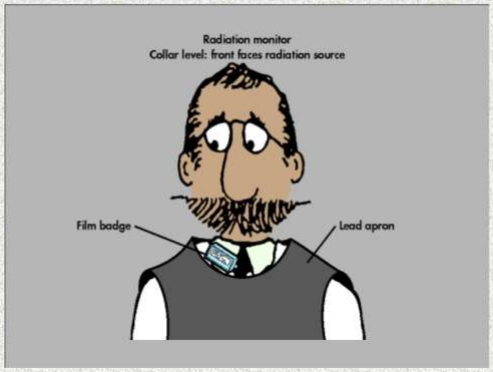
Occupational radiation monitor does NOT protect against radiation exposure!



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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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP TESTING
NVLAP LAB CODE 100518-0

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LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

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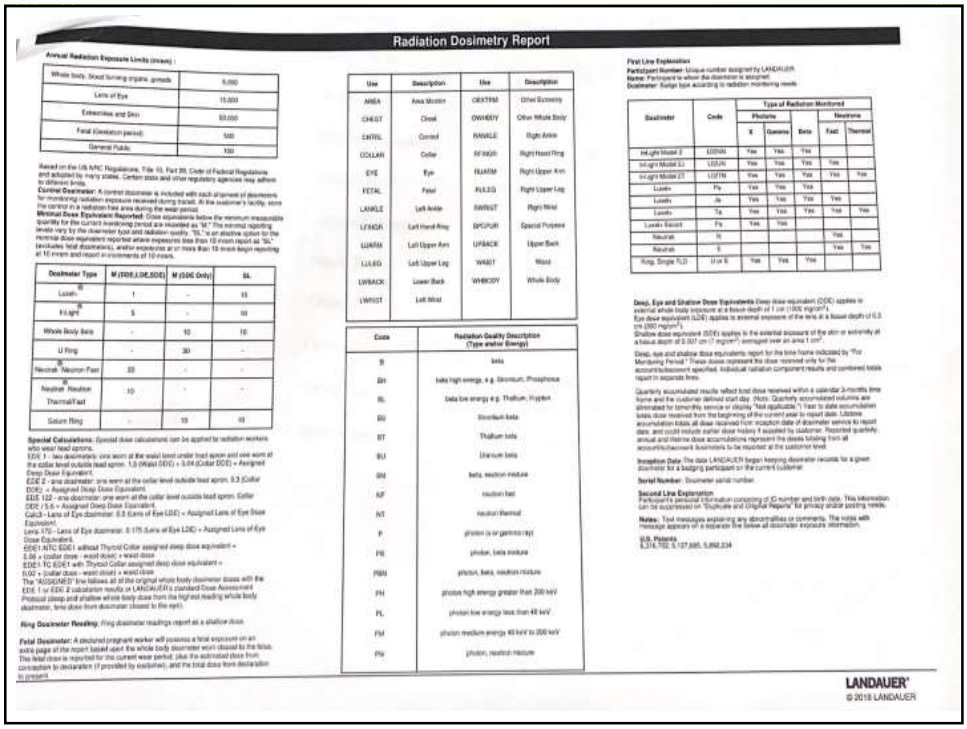

Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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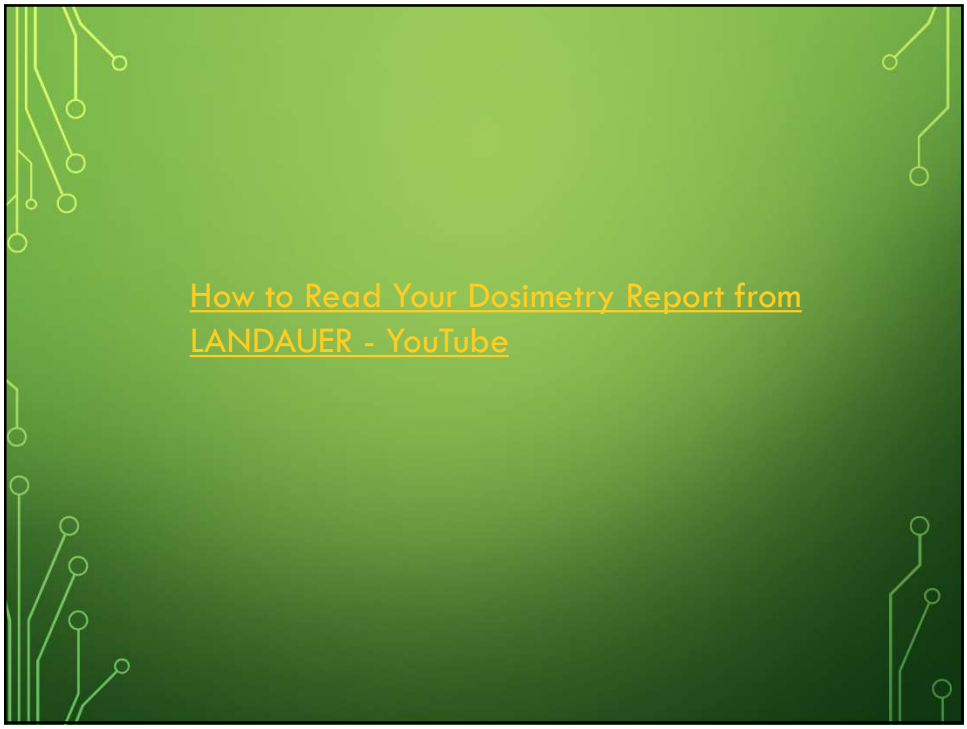

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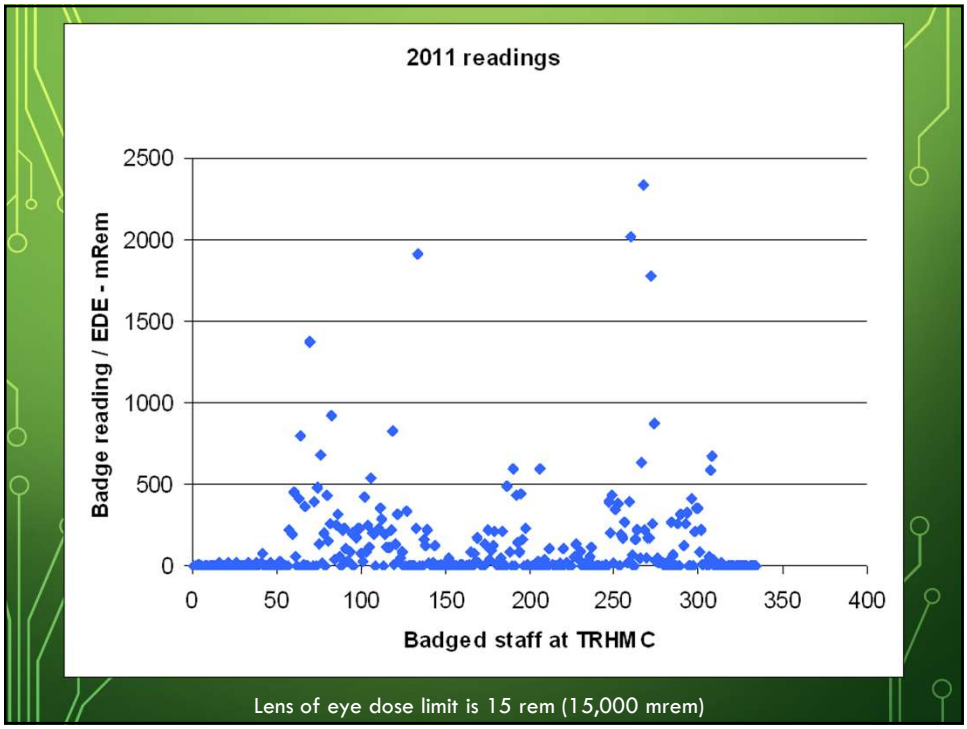
2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

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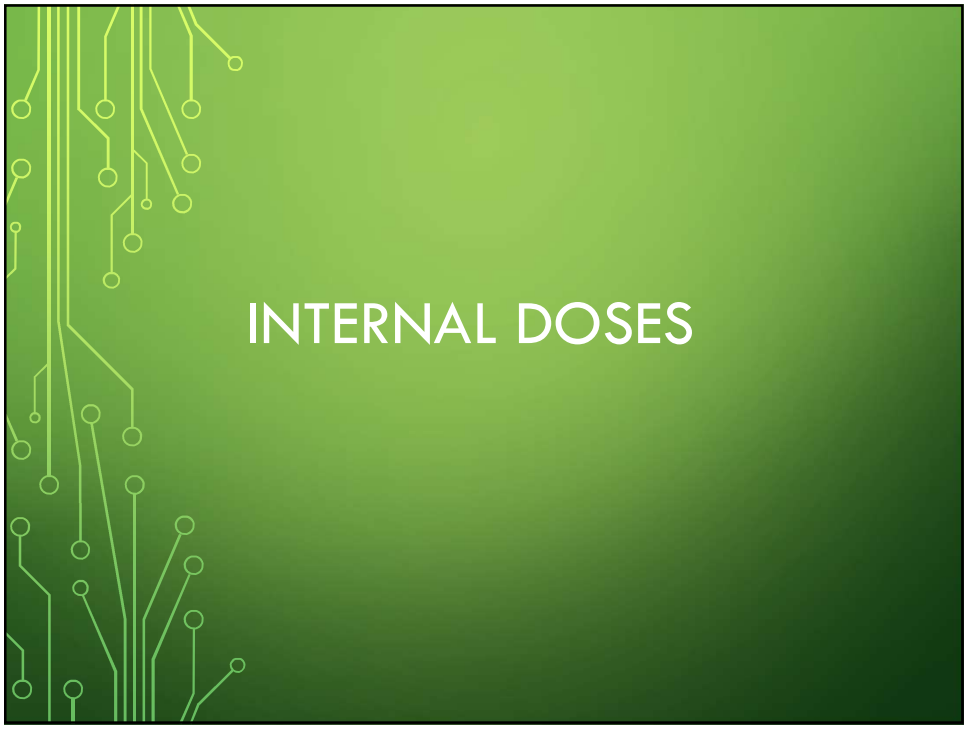
INTERNAL DOSES

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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

From NCRP 160

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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 INSTRUMENTS

- 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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

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"CUTIE PIE"

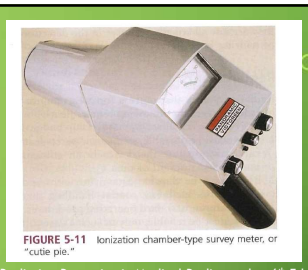

FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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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REVIEW QUESTIONS

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WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

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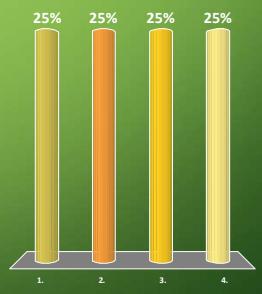
WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



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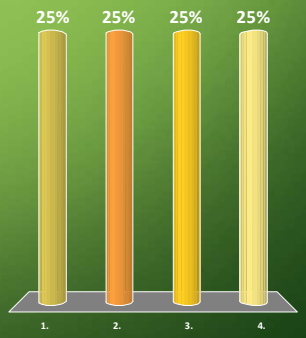
WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

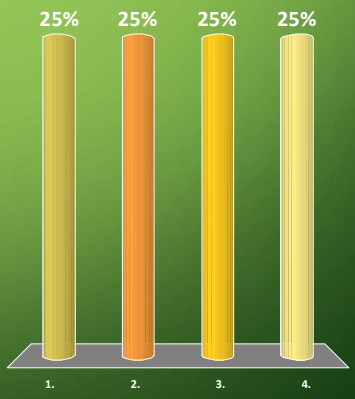
1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



52

WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

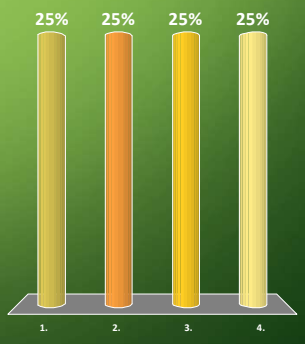
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

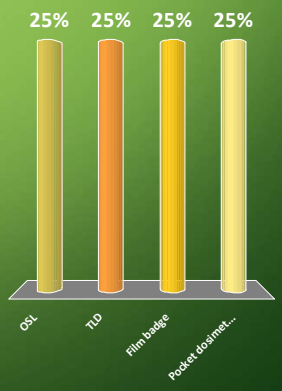
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

56

57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

10

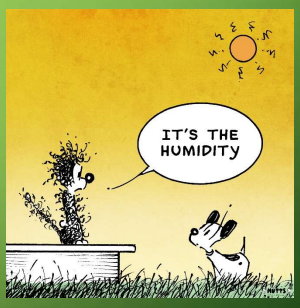
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 be sent out to be read



12

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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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

16

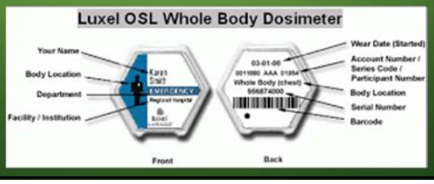
OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

17

OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

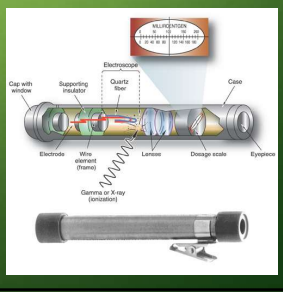
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

23

DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

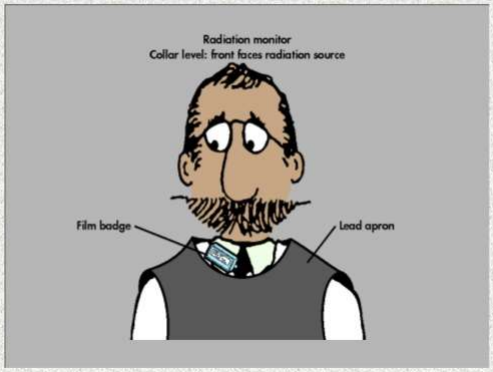
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

Occupational radiation monitor does NOT protect against radiation exposure!



27

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

29

READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP LAB CODE 100518-0

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Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

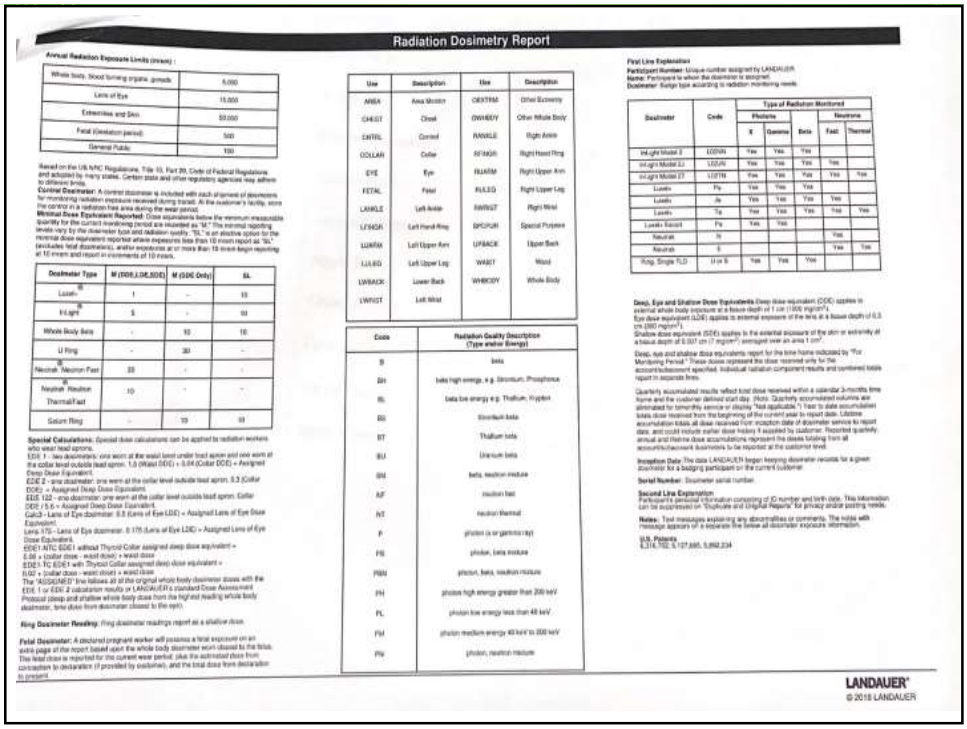
Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

30



Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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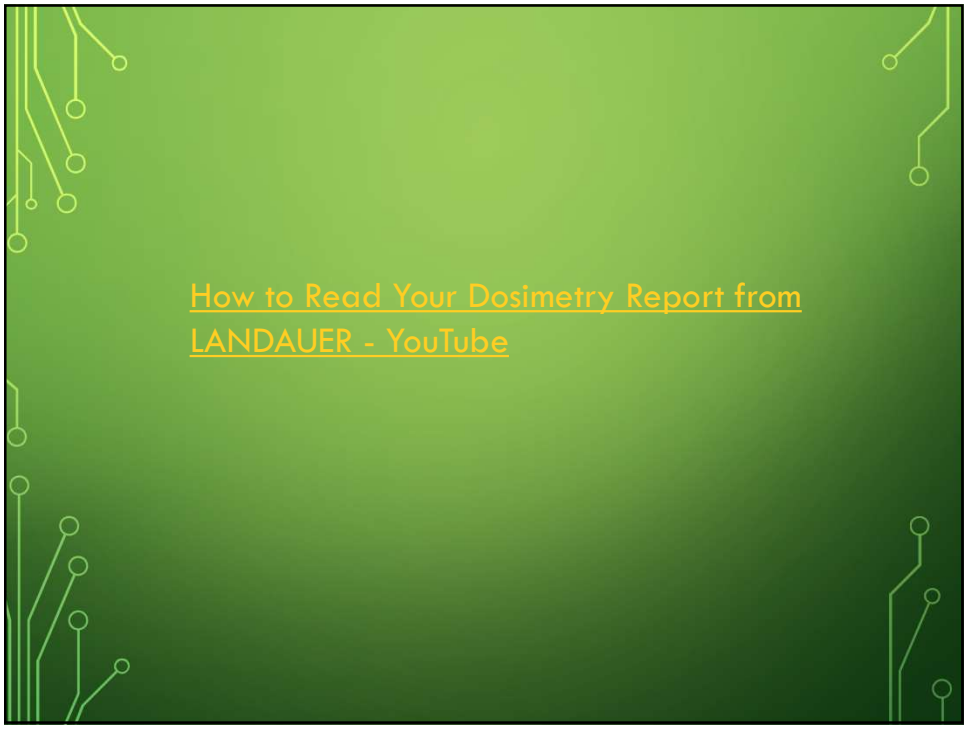

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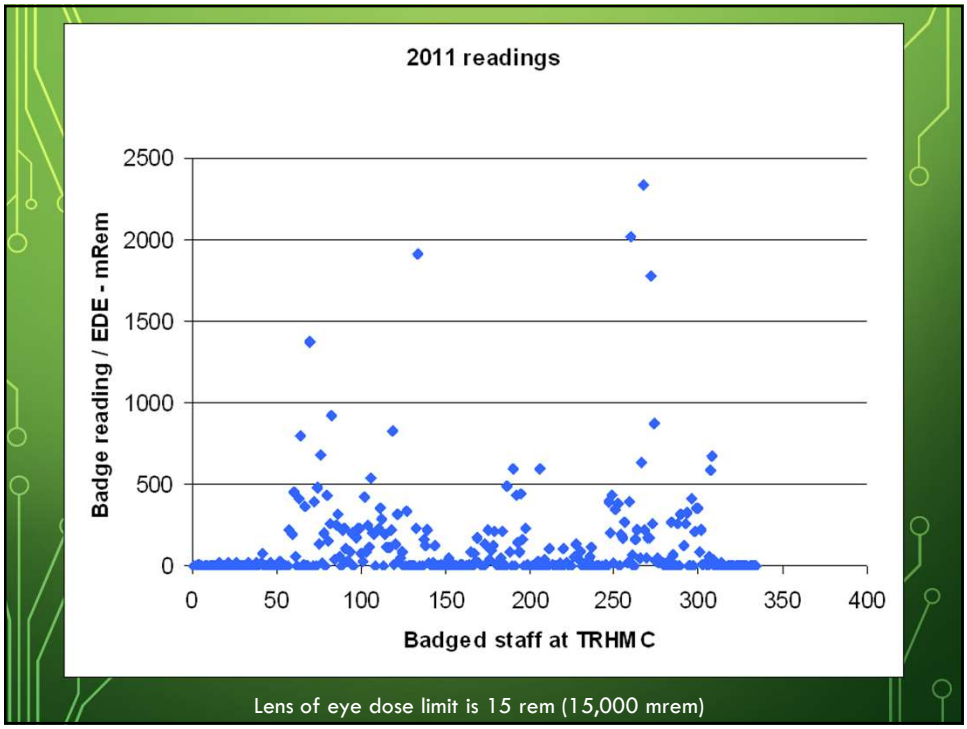
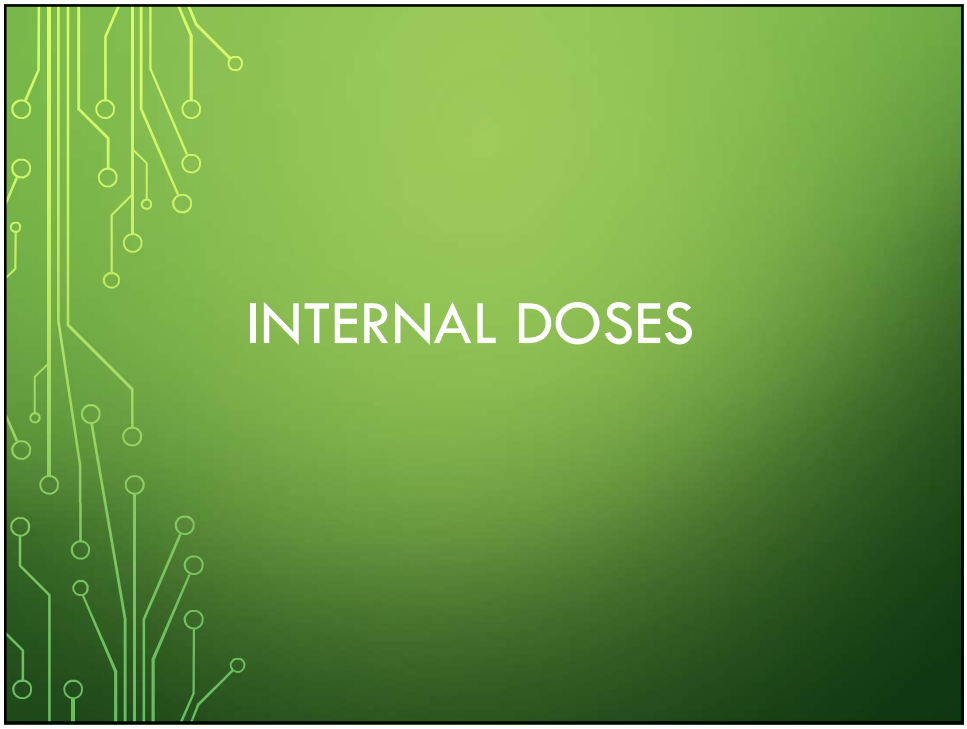

2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

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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

From NCRP 160

35

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…..

37

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 INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

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"CUTIE PIE"

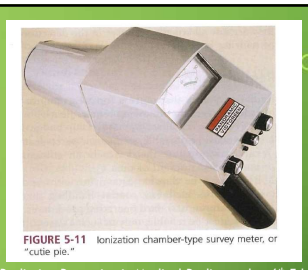

FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

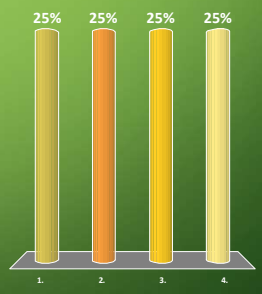
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

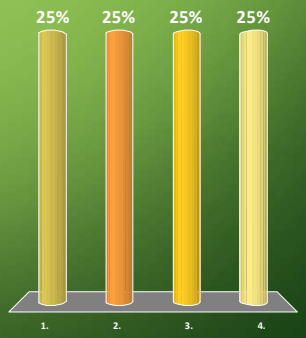
1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



51

WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

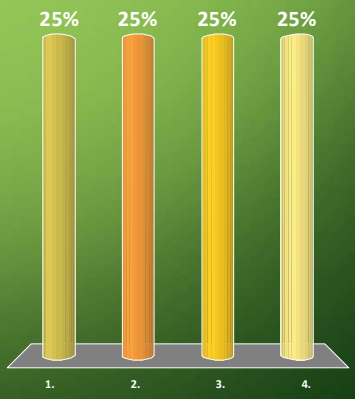
1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



52

WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

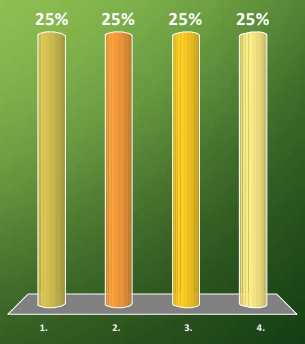
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

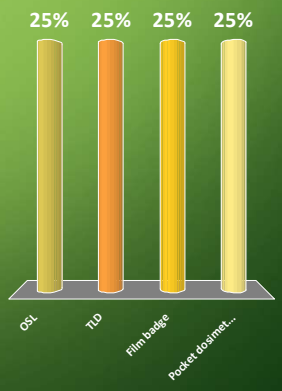
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

56

57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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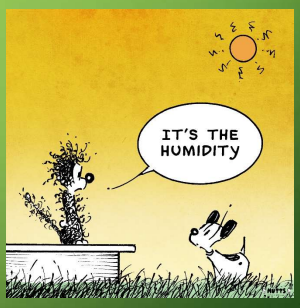
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 be sent out to be read



12

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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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

16

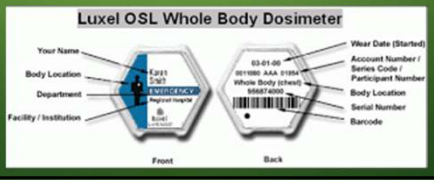
OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

17

OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

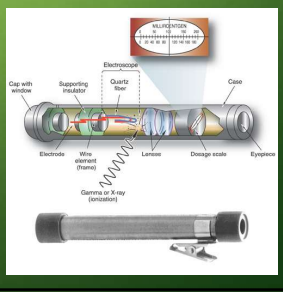
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

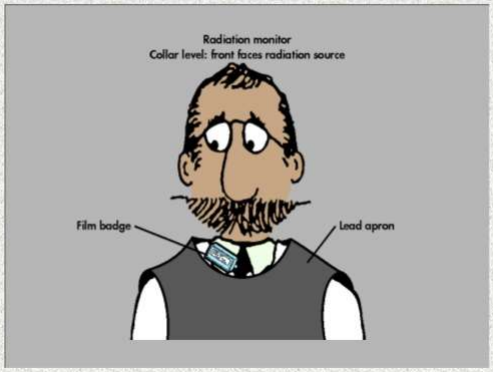
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP TESTING
NVLAP LAB CODE 100518-0

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Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

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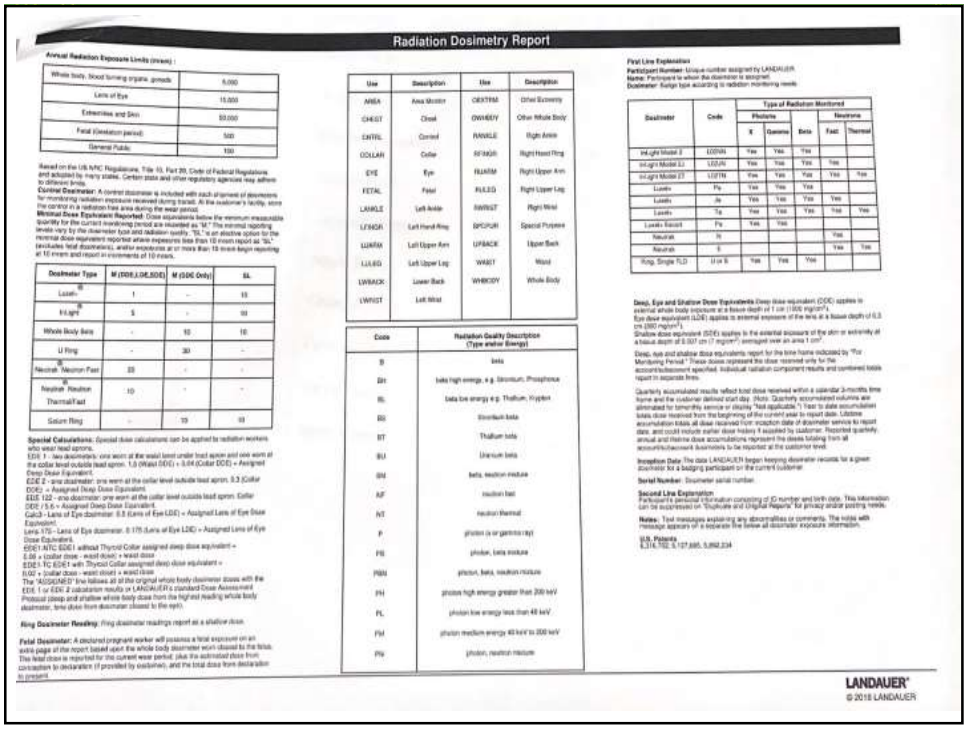

Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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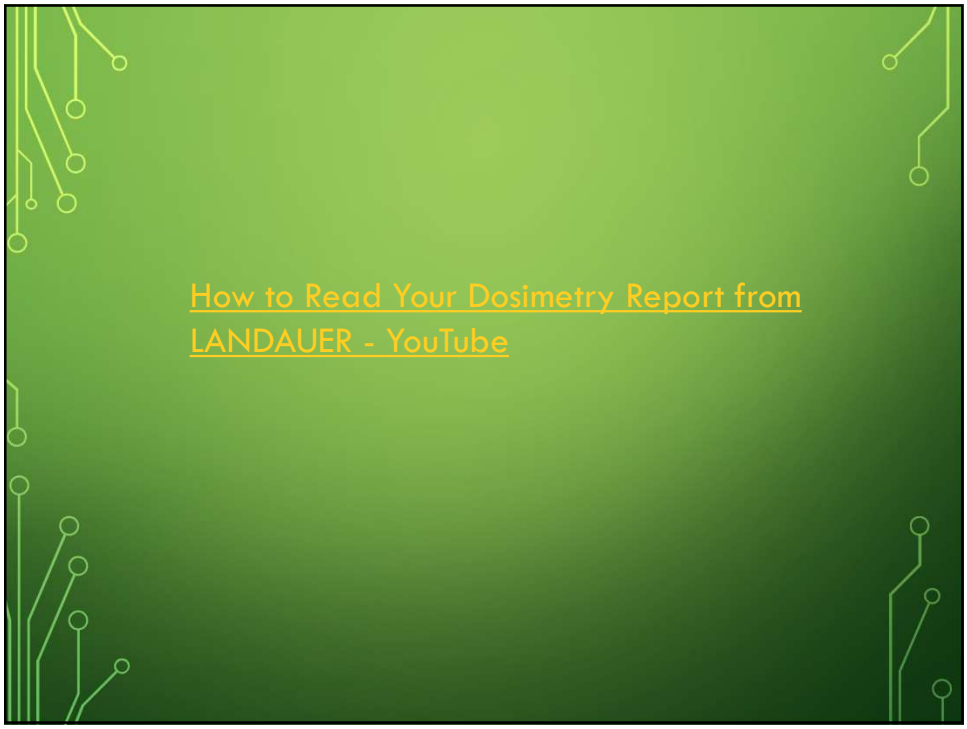

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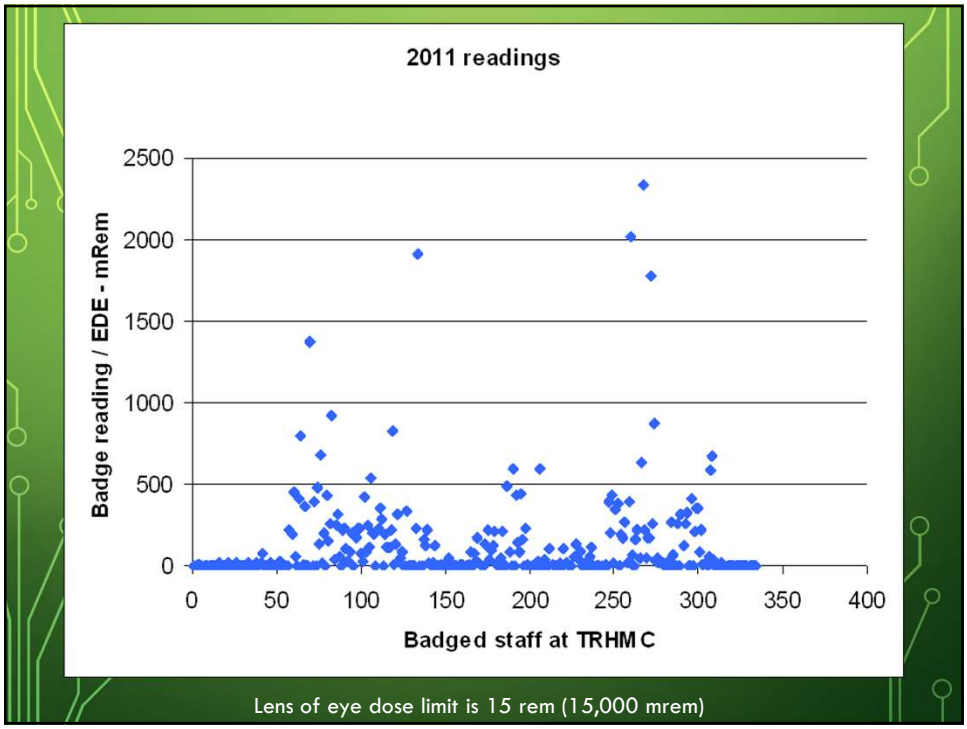
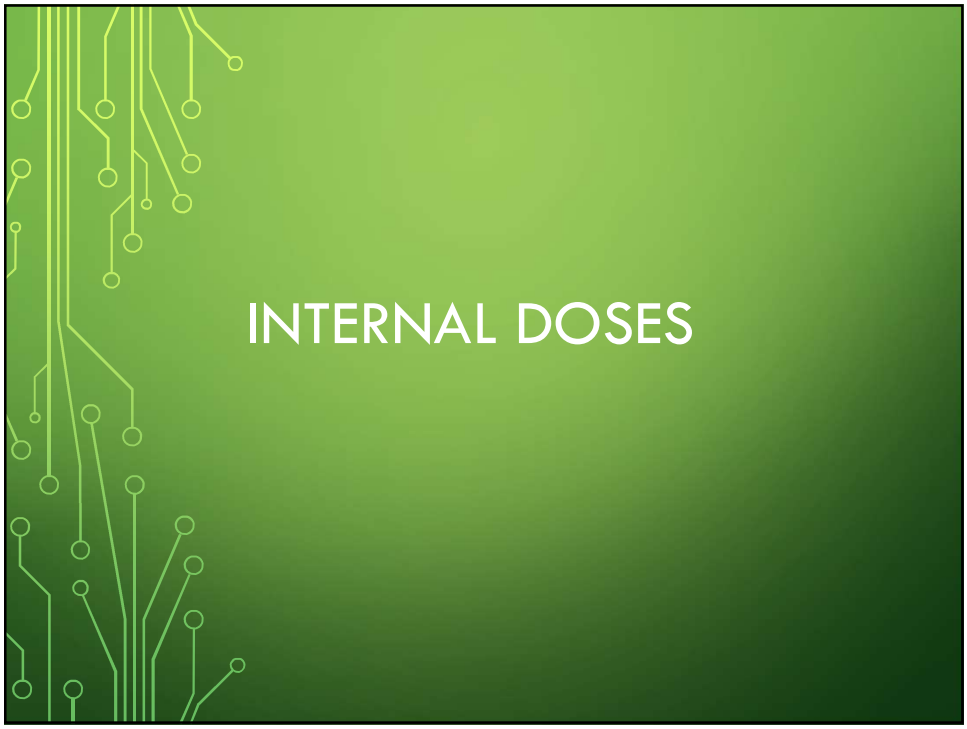

2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

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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

From NCRP 160

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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…..

37

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

39

GAS FILLED RADIATION SURVEY INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

41

"CUTIE PIE"

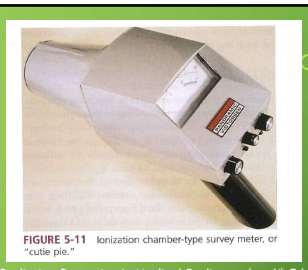

FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

43

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.

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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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

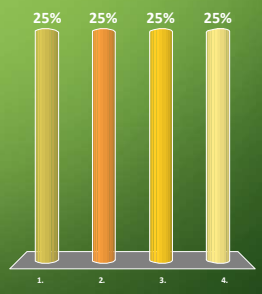
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



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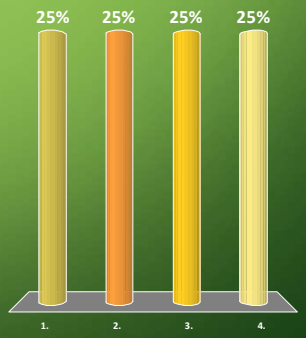
WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



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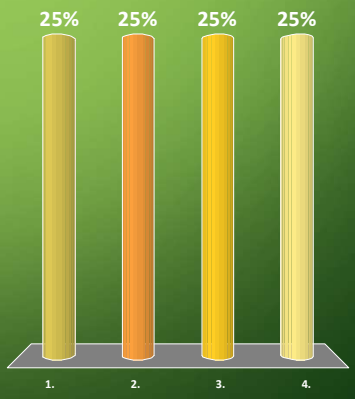
WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

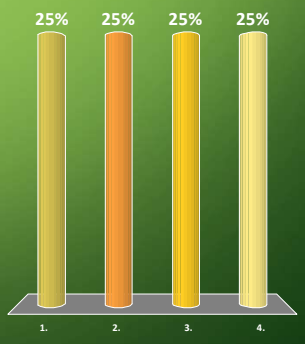
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

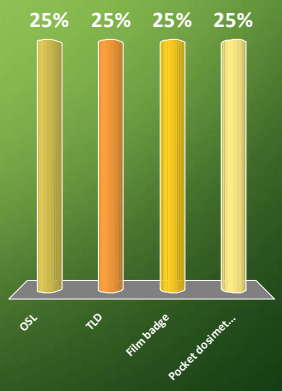
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

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57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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Statkiewicz Sherer

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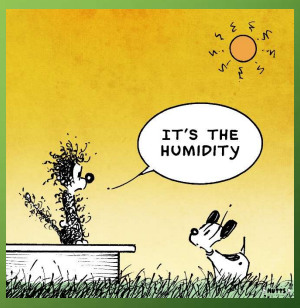
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

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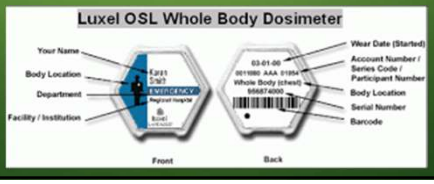
OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

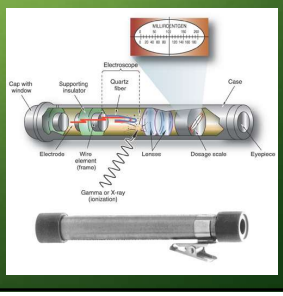
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

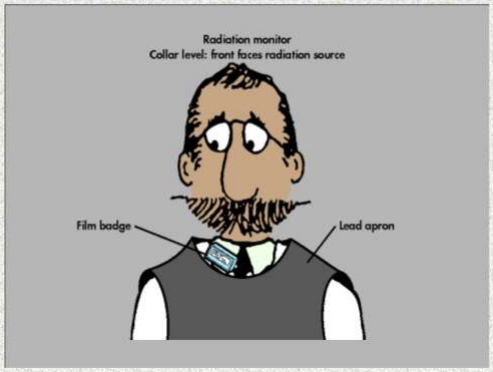
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP TESTING
NVLAP LAB CODE 100518-0

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LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

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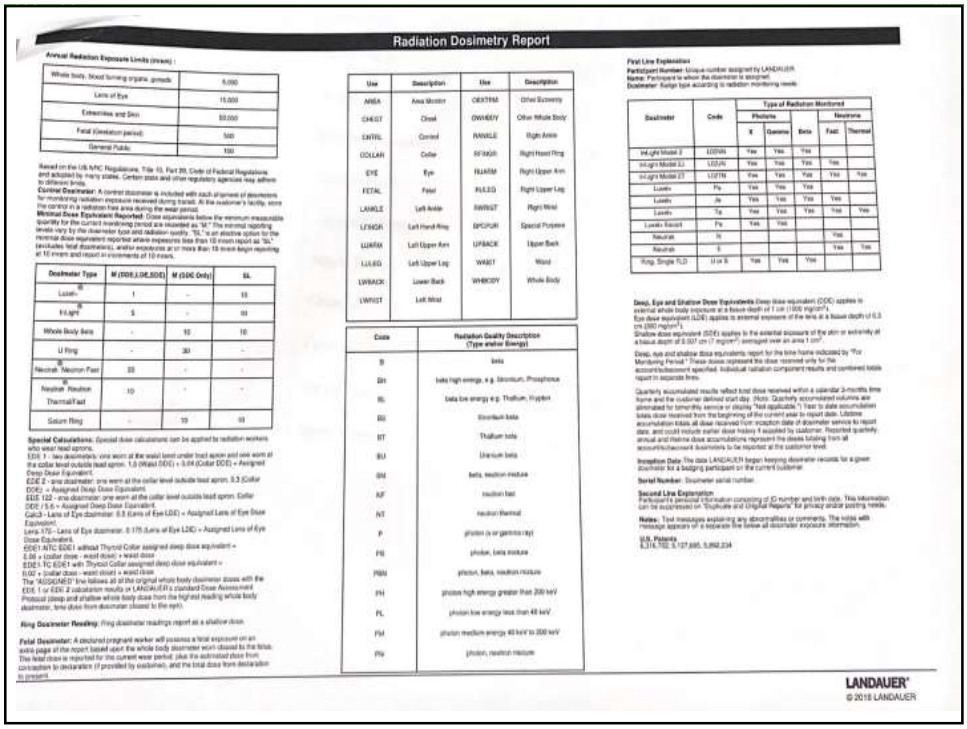

Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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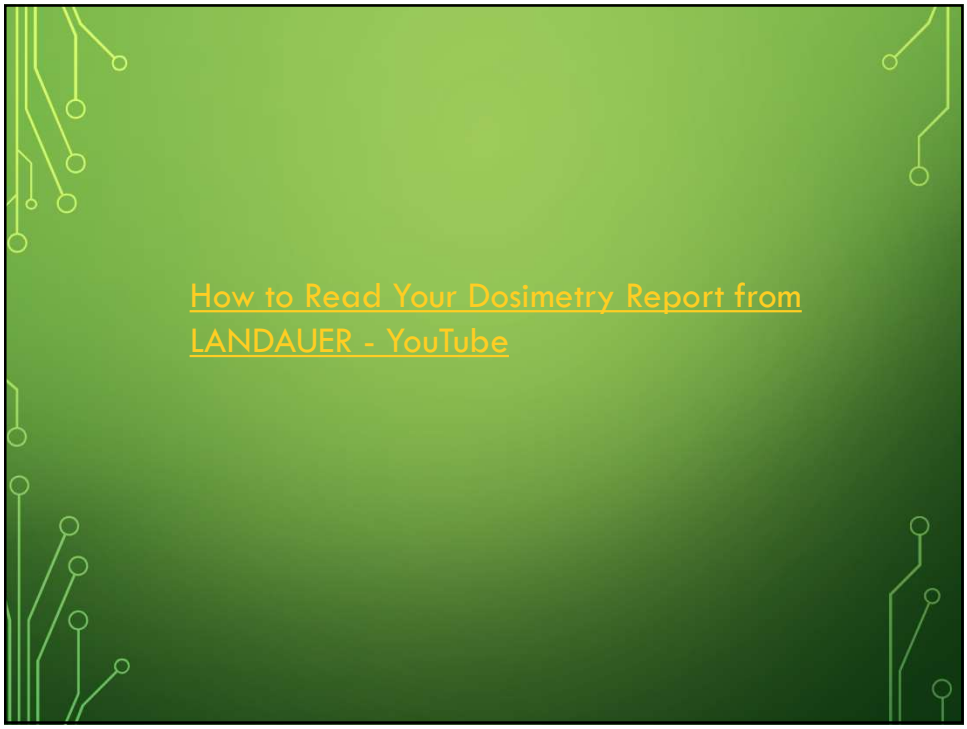
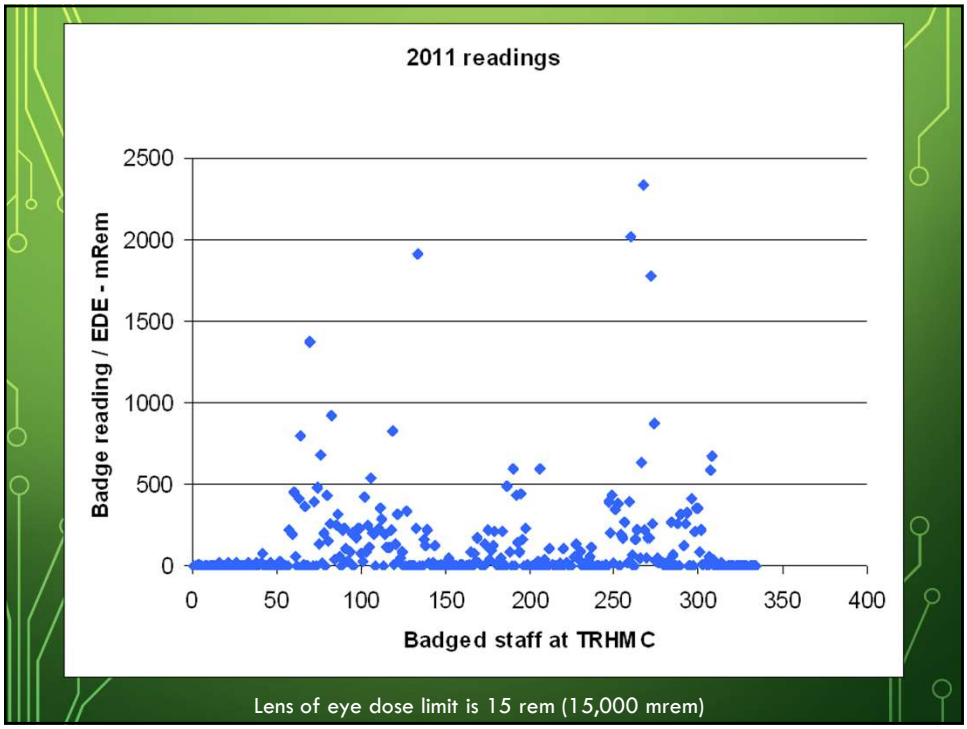
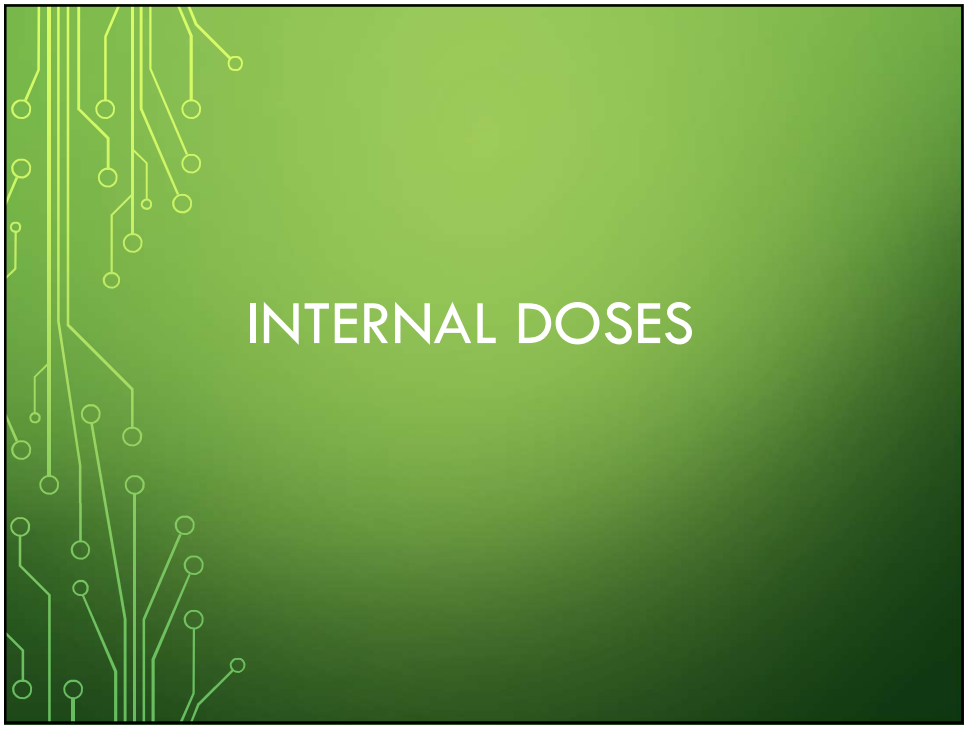
31



32


2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

34

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

From NCRP 160

35

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

36

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…..

37

RADIATION SURVEYS INSTRUMENTS

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

38

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

39

GAS FILLED RADIATION SURVEY INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

41

"CUTIE PIE"

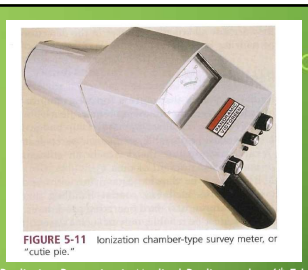


FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

42

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

43

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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

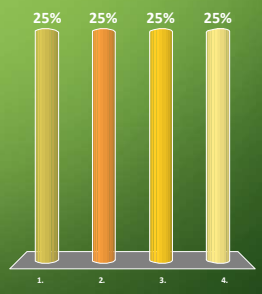
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

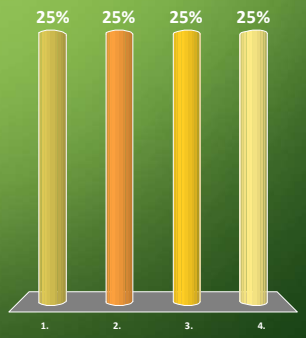
1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



51

WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

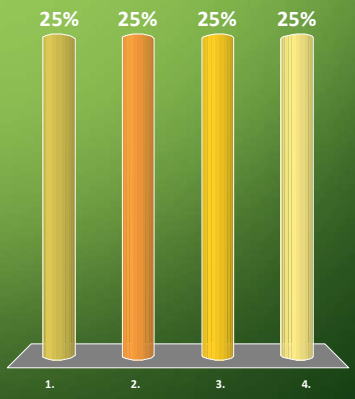
1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



52

WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

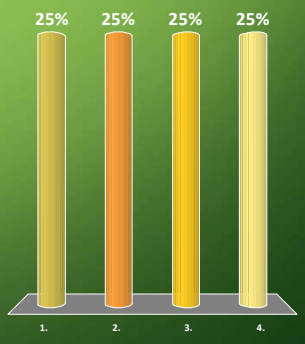
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

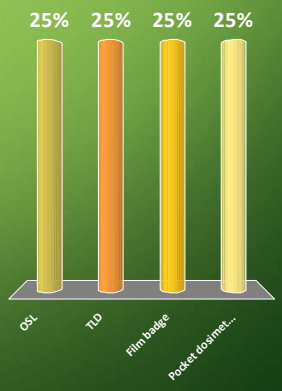
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

56

57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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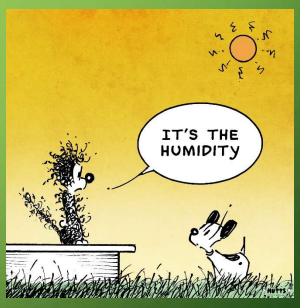
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 be sent out to be read



12

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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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

16

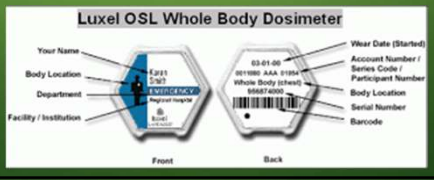
OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

17

OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

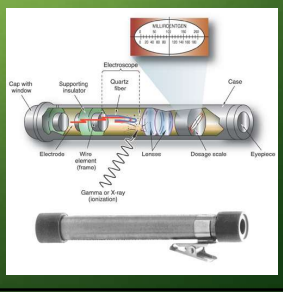
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

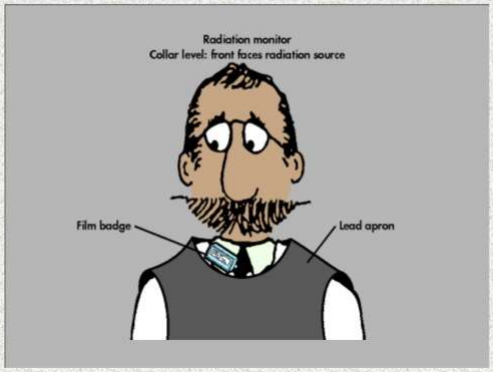
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
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Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

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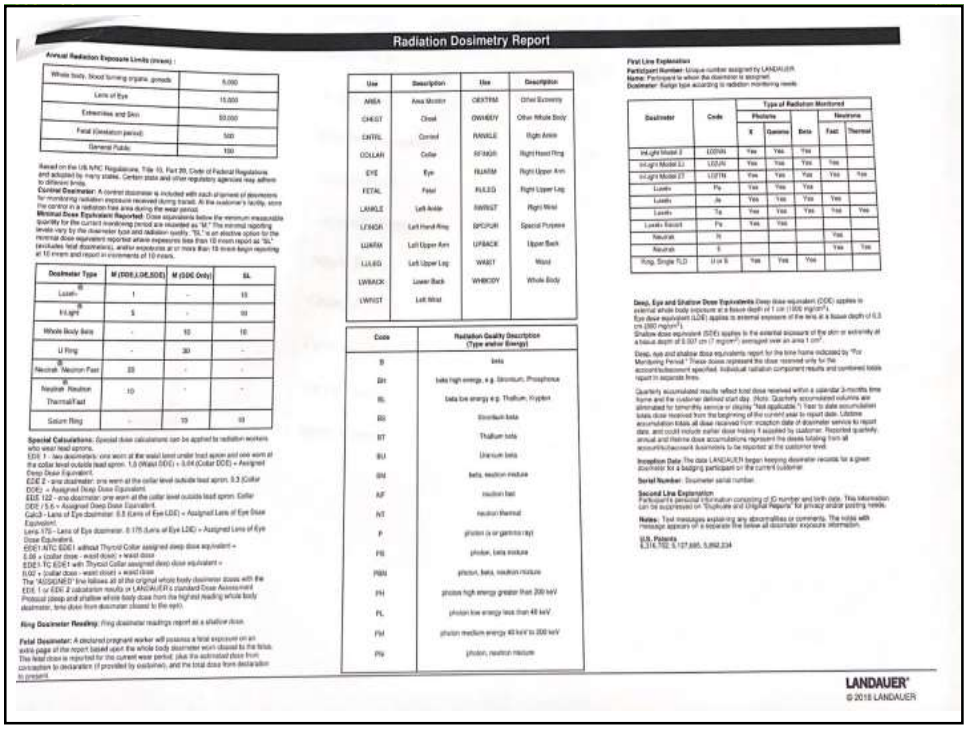

Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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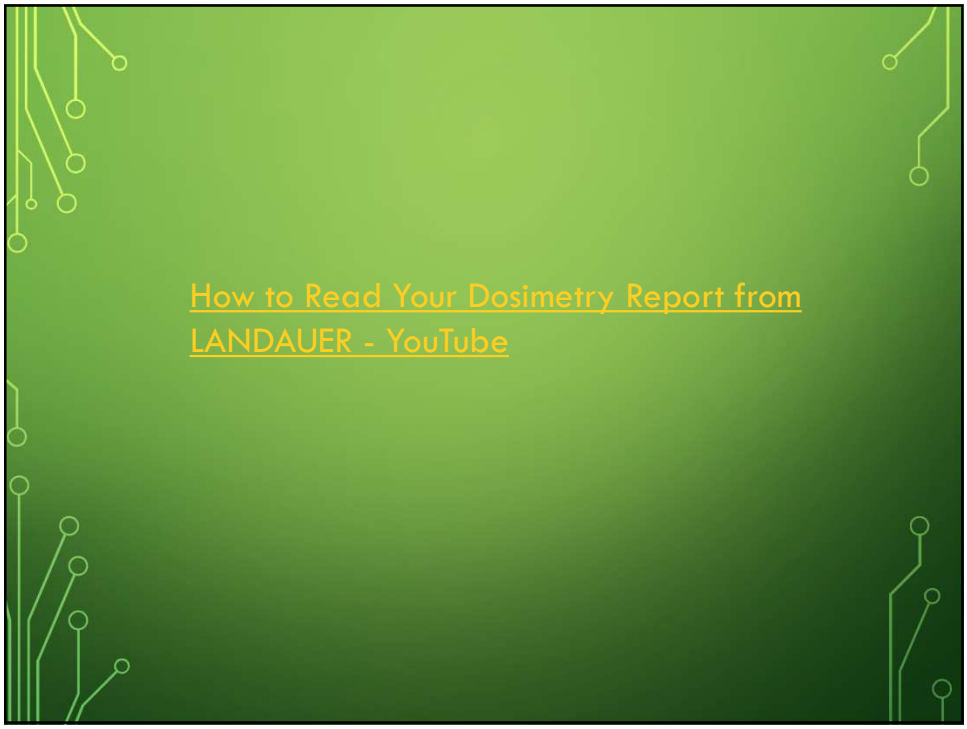
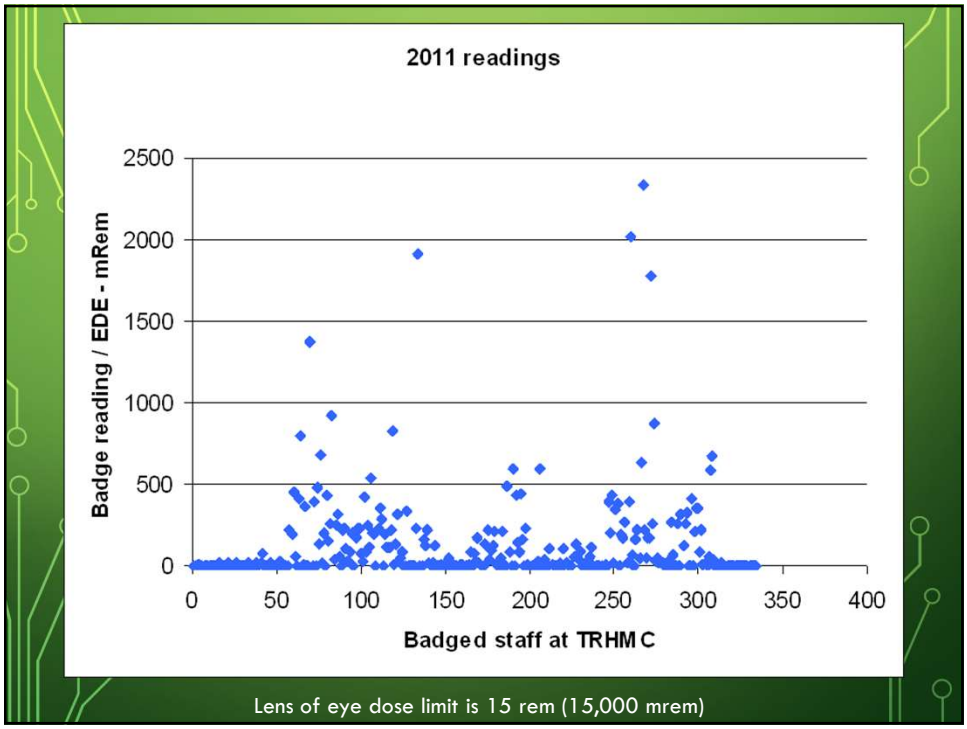
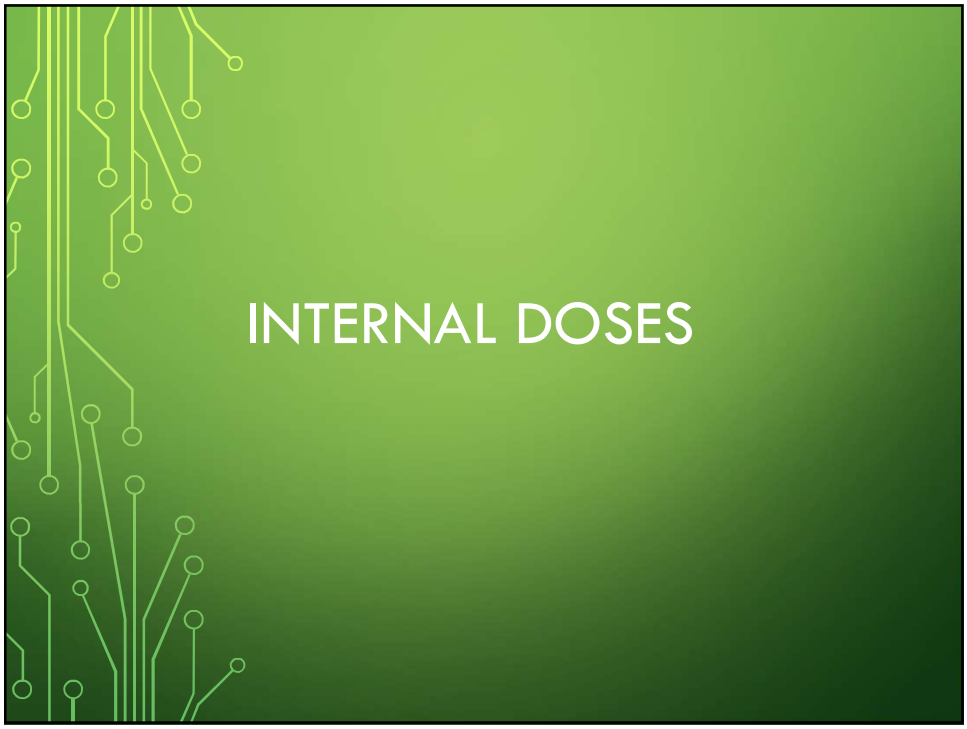
31



32


2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

34

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

From NCRP 160

35

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

36

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…..

37

RADIATION SURVEYS INSTRUMENTS

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

38

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

39

GAS FILLED RADIATION SURVEY INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

41

"CUTIE PIE"

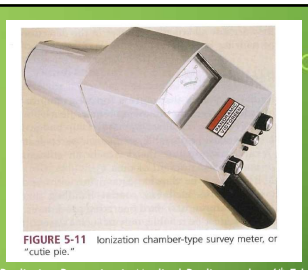


FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

43

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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

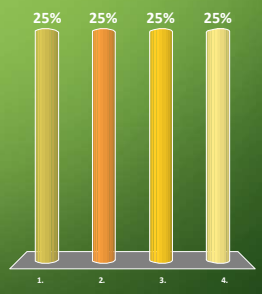
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

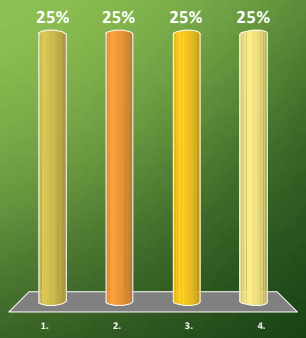
1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



51

WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

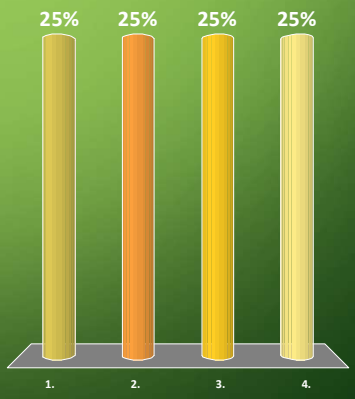
1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



52

WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

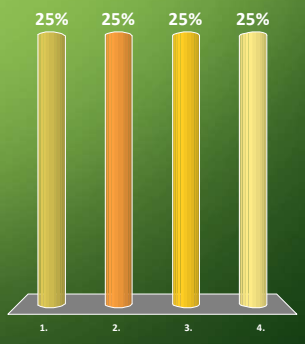
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

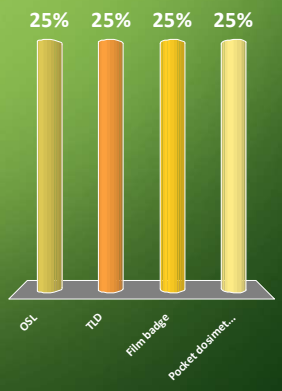
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

56

57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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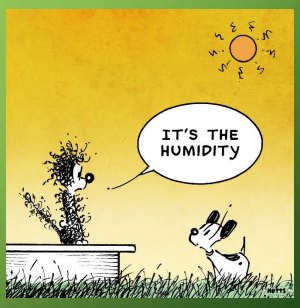
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 be sent out to be read



12

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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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

16

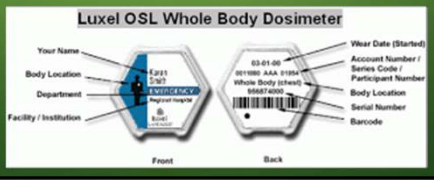
OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

17

OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

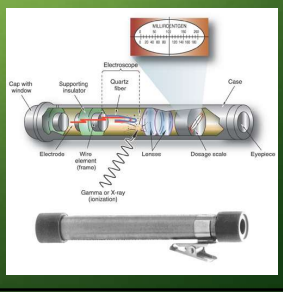
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

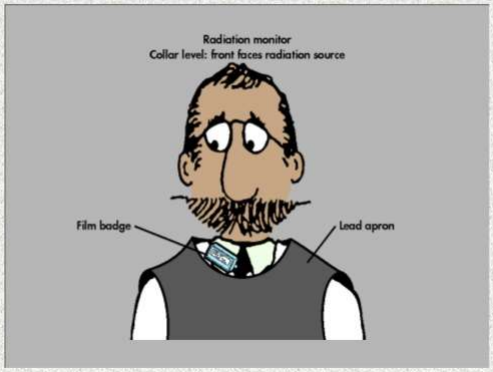
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

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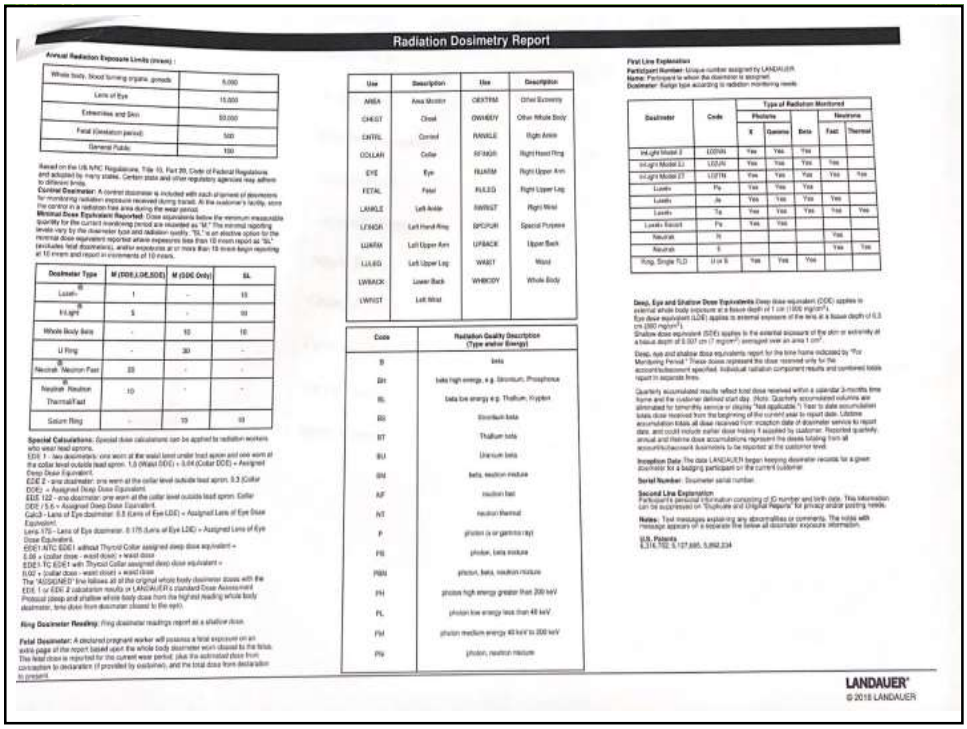

Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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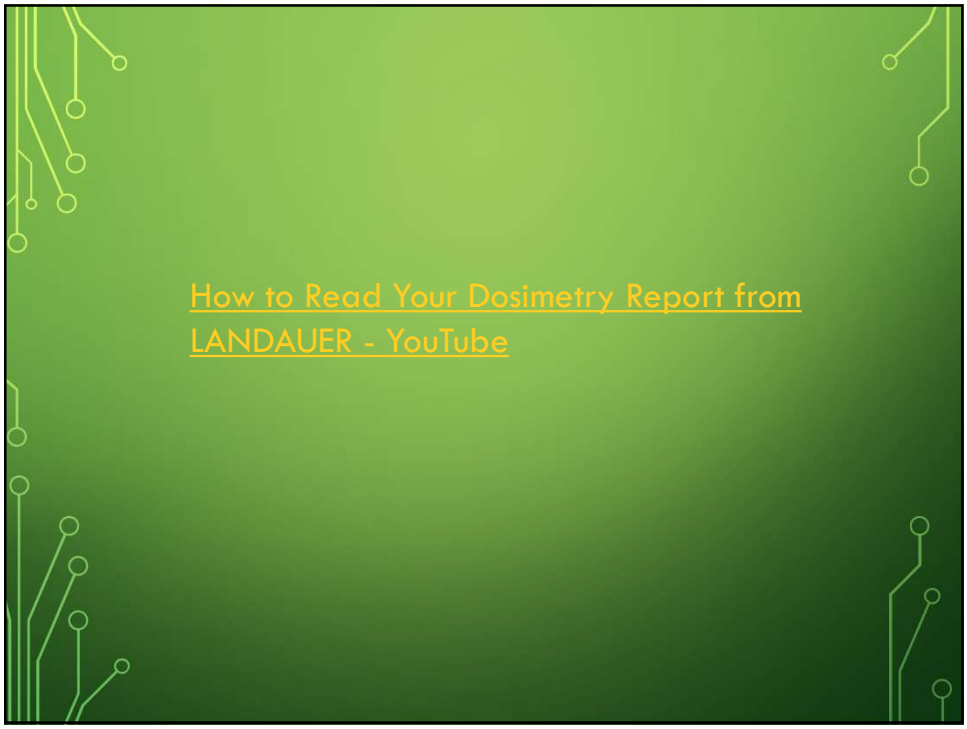
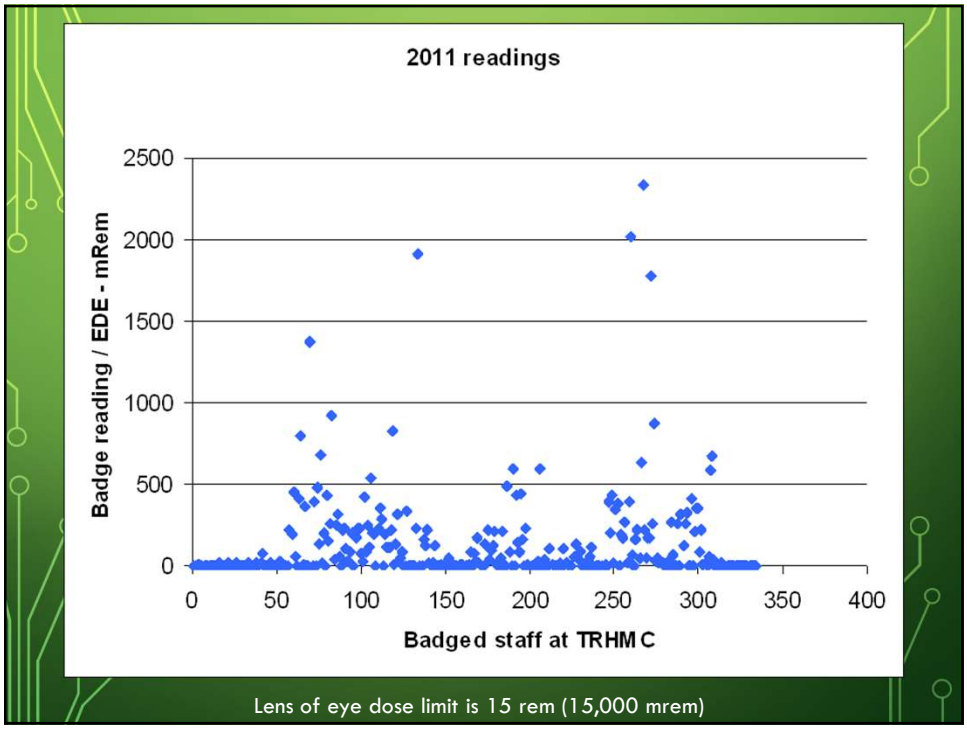
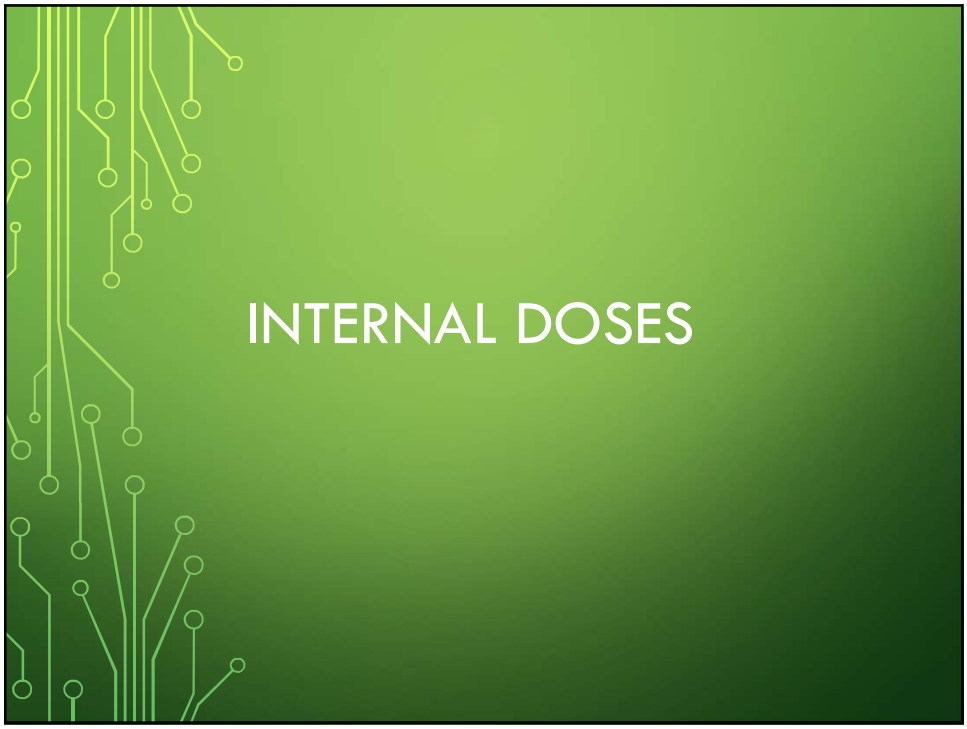


32


2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

34

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

From NCRP 160

35

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

36

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…..

37

RADIATION SURVEYS INSTRUMENTS

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

38

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

39

GAS FILLED RADIATION SURVEY INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

41

"CUTIE PIE"

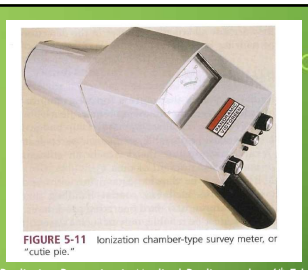


FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

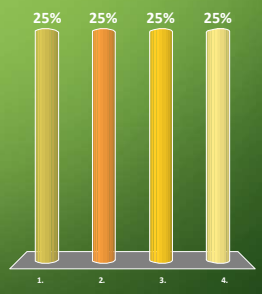
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



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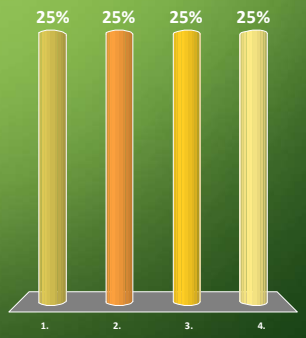
WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



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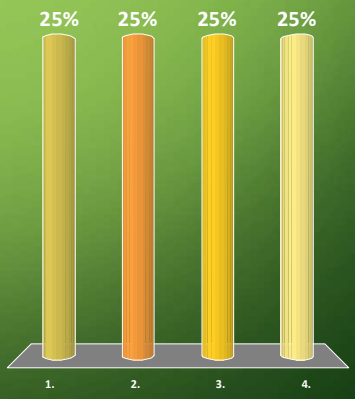
WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

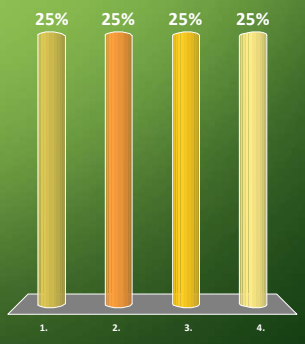
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

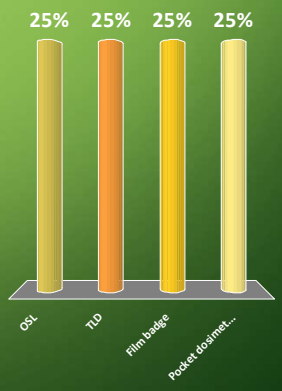
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

56

57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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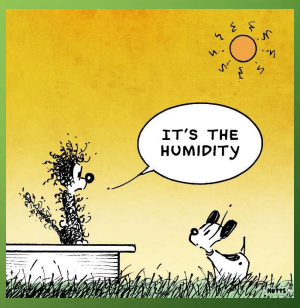
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 be sent out to be read



12

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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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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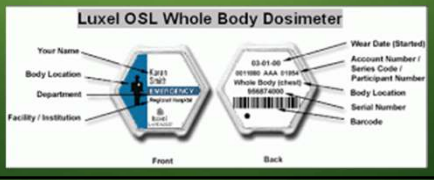
OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

17

OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

OSL DISADVANTAGES

- Only records exposure to area where it's worn
- 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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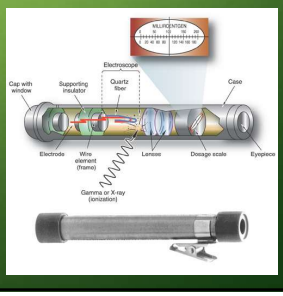
POCKET IONIZATION CHAMBER

- 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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

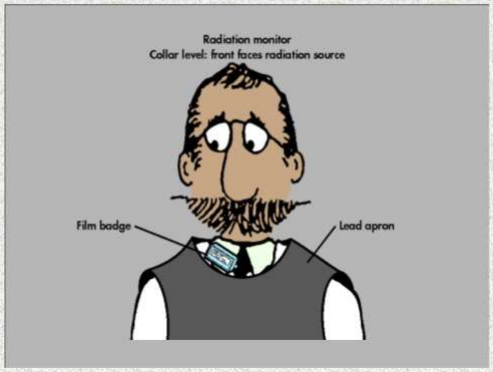
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
Copy / Version	0 / 1

NVLAP TESTING
NVLAP LAB CODE 100518-0

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LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

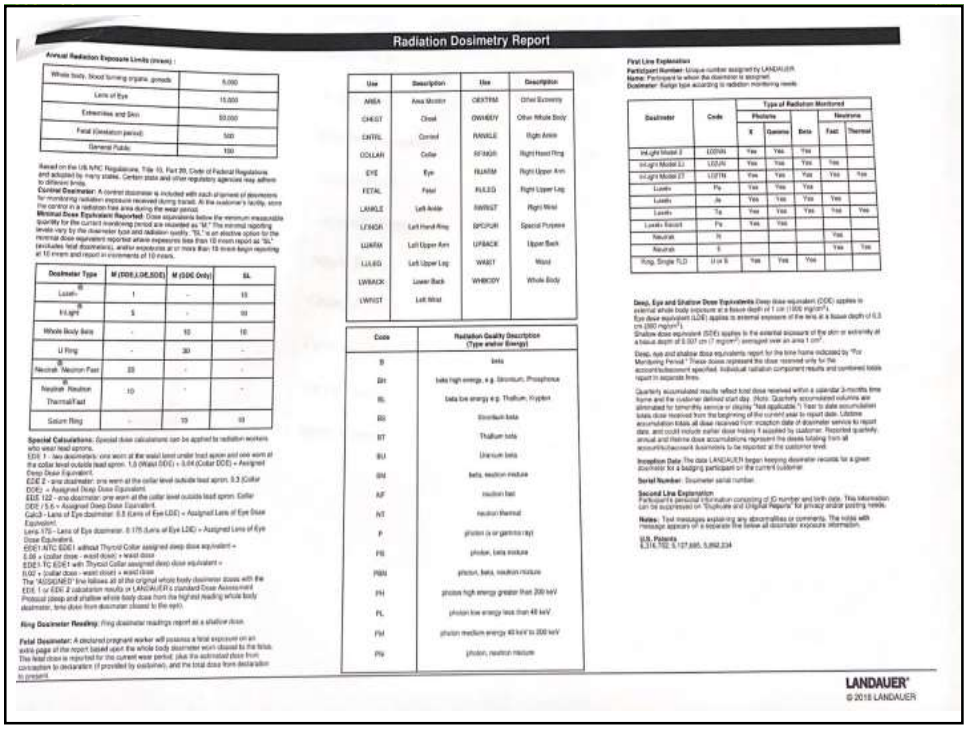
Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

30



Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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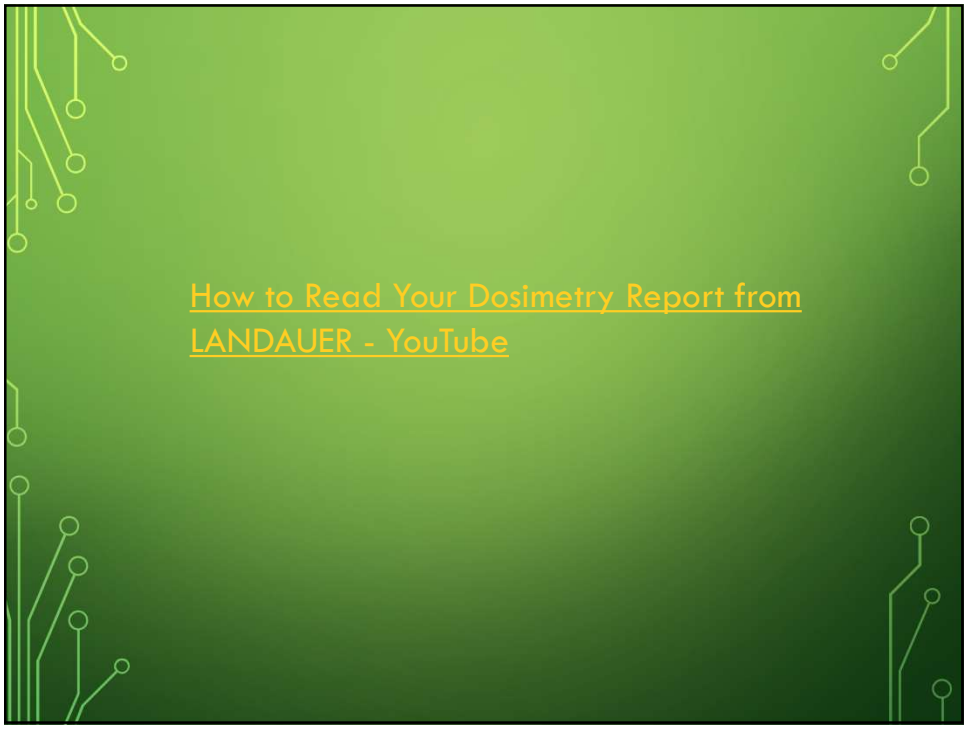
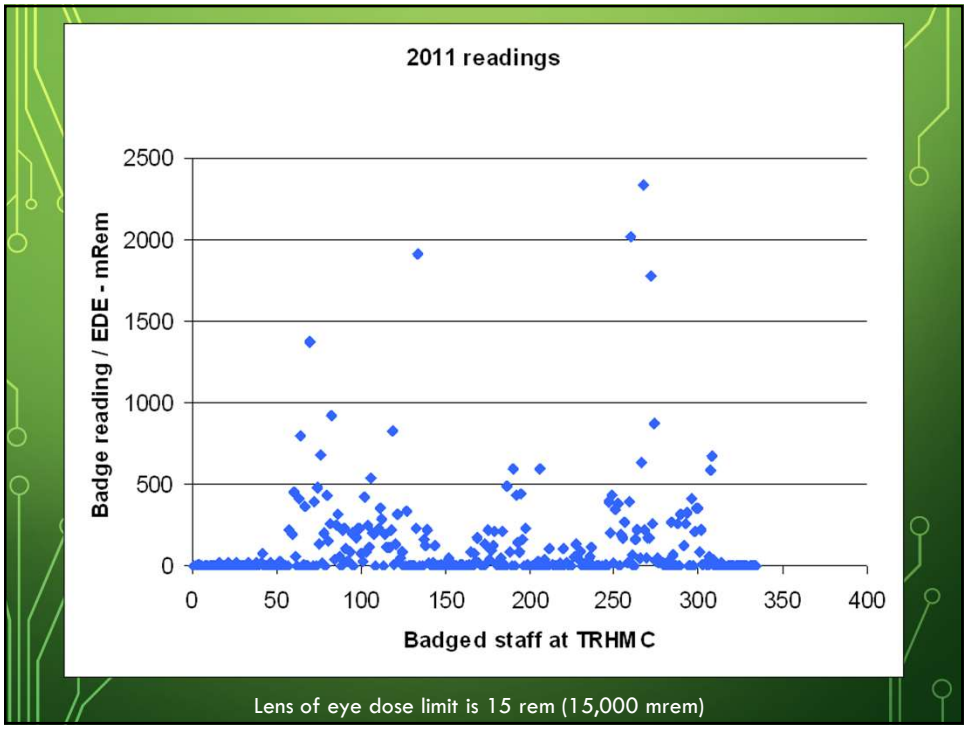
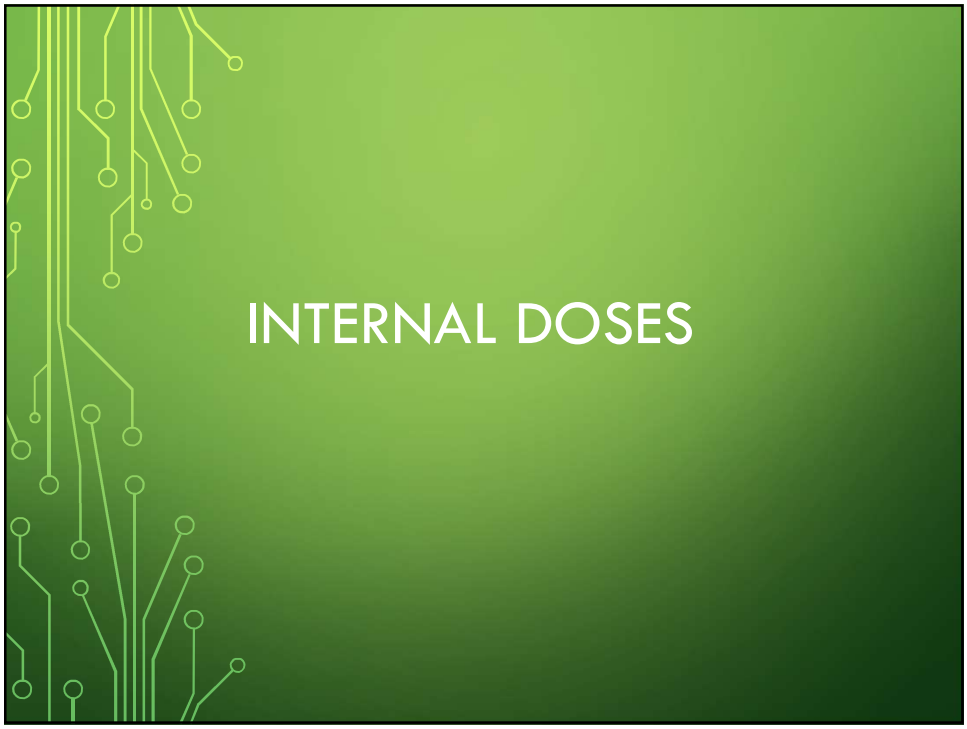


32


2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

34

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

From NCRP 160

35

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

36

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…..

37

RADIATION SURVEYS INSTRUMENTS

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

38

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

39

GAS FILLED RADIATION SURVEY INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

41

"CUTIE PIE"

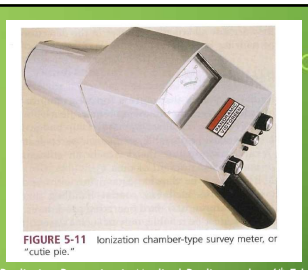


FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

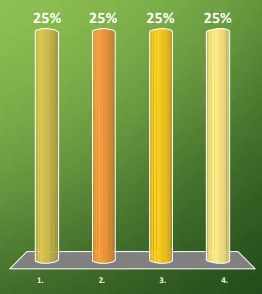
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

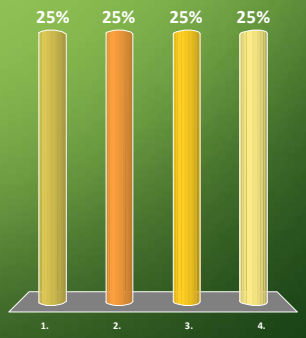
1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



51

WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



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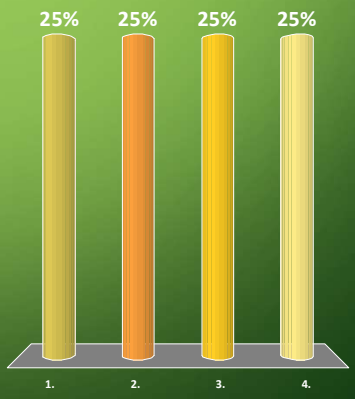
WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

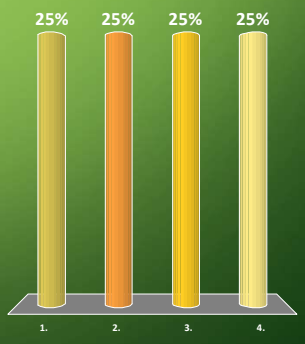
1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



53

WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

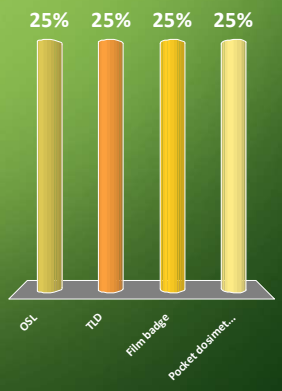
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

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57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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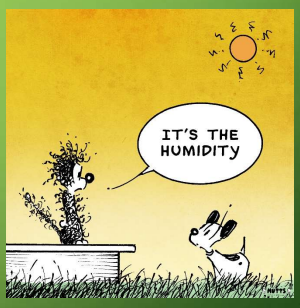
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 be sent out to be read



12

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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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

16

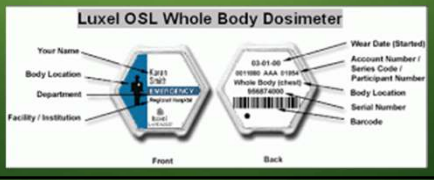
OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

17

OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

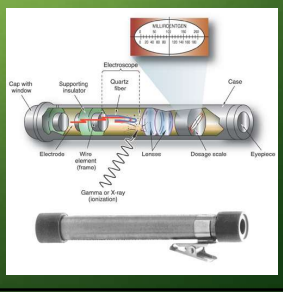
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

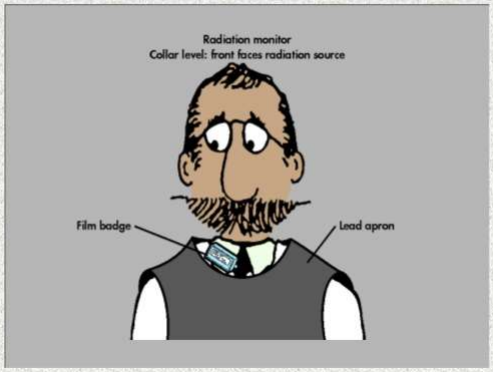
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

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READING HOSPITAL
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Received Date / Reported Date	2022-03-18 / 2022-03-25
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Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP TESTING
NVLAP LAB CODE 100518-0

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Radiation Dosimetry Report

Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

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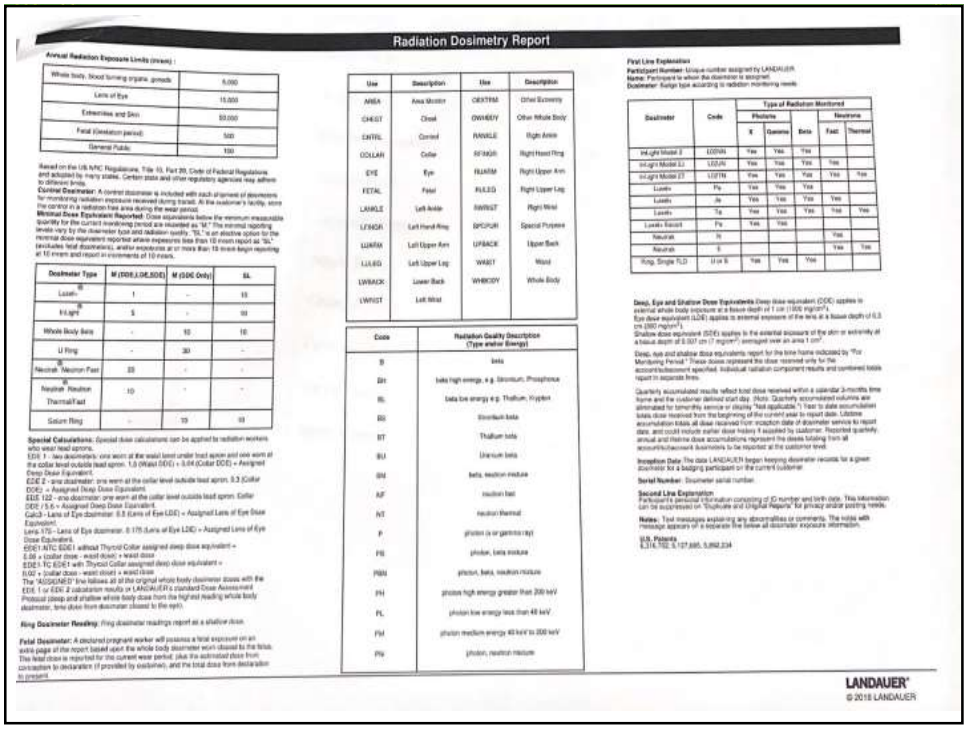

Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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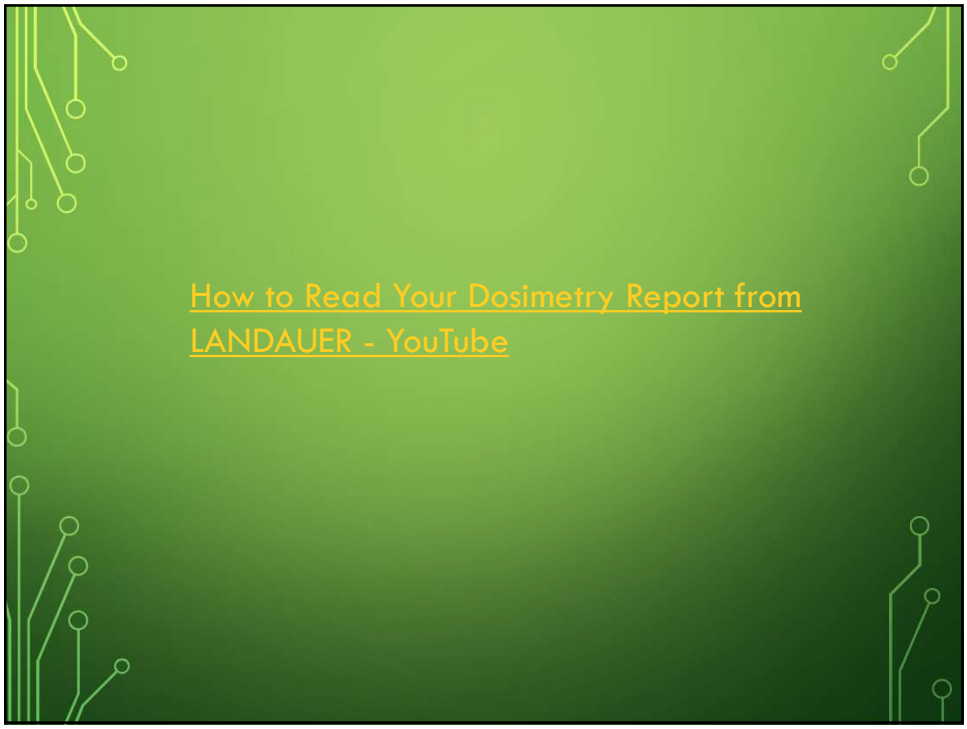

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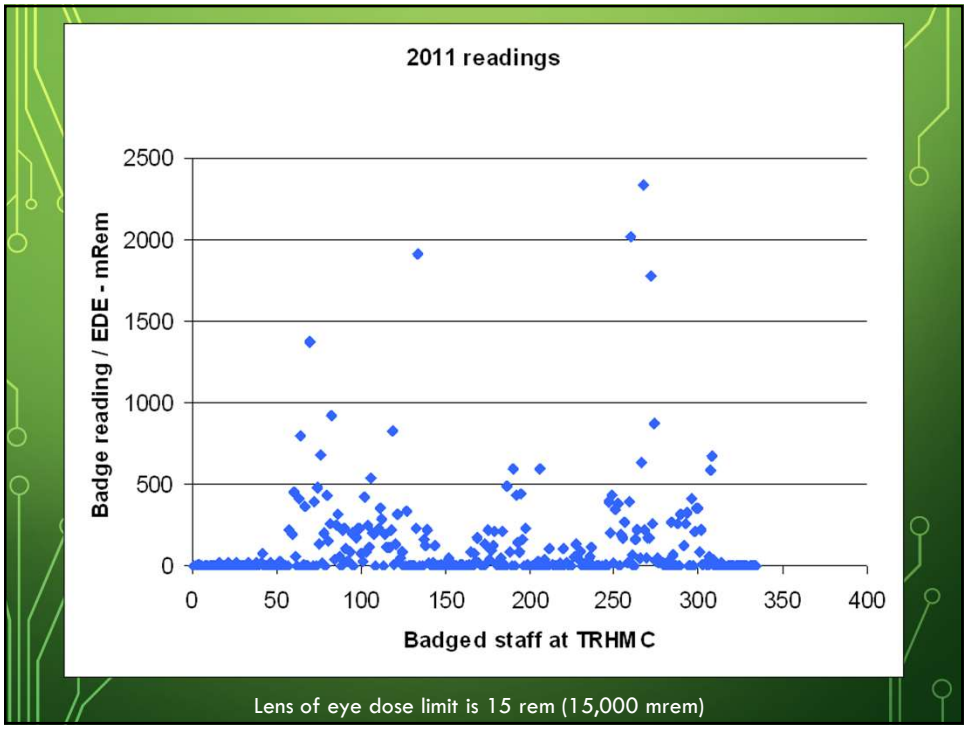
2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

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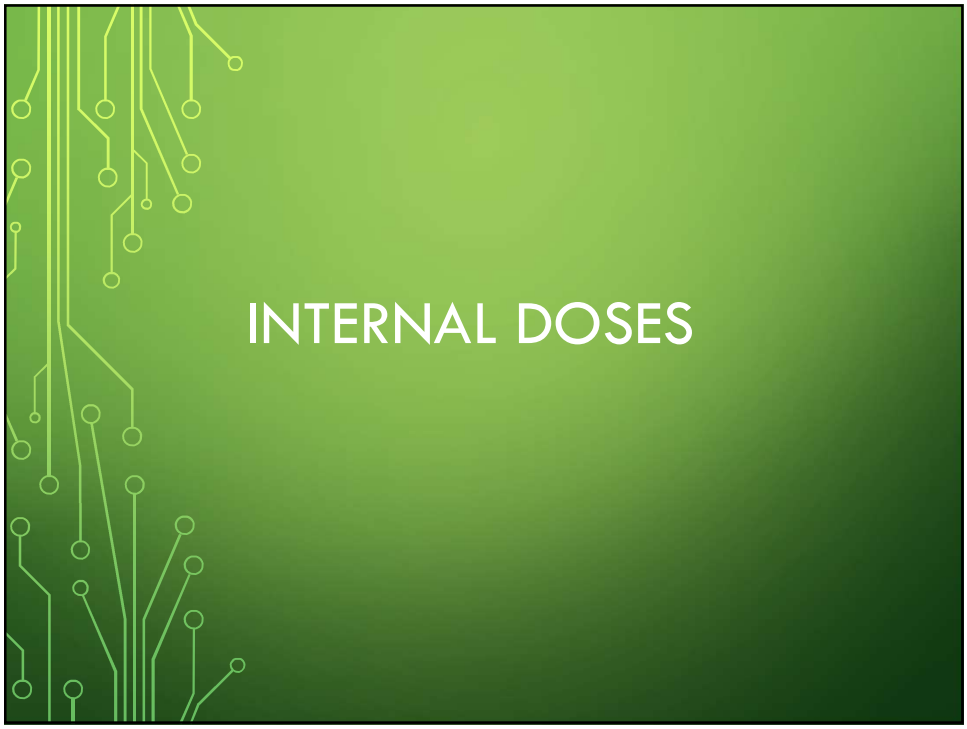
INTERNAL DOSES

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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

From NCRP 160

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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 INSTRUMENTS

- 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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

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"CUTIE PIE"

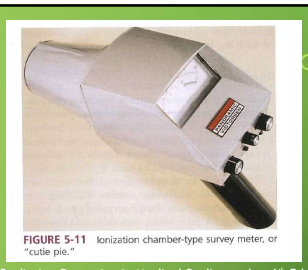

FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

45

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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REVIEW QUESTIONS

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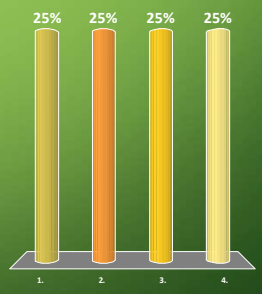
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



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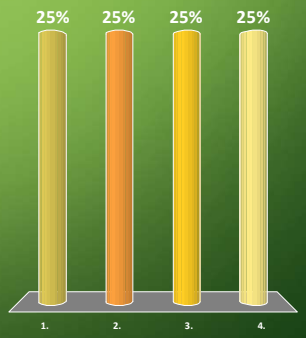
WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



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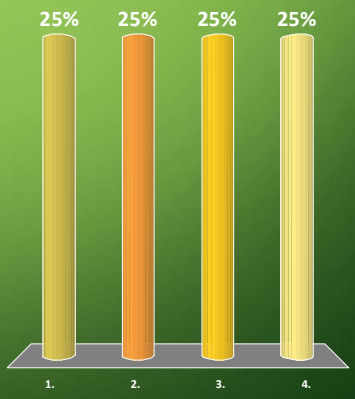
WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



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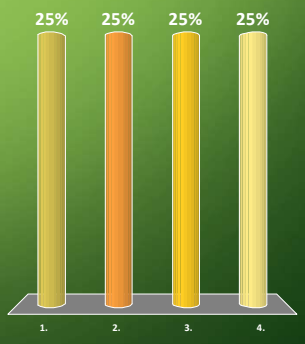
WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

1. Daily
2. Monthly
3. Quarterly
4. Yearly



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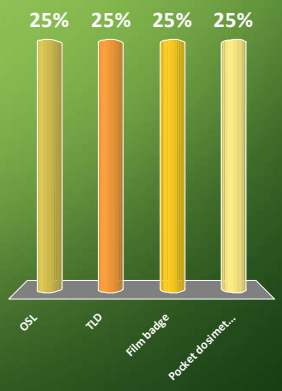
WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



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WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

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Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

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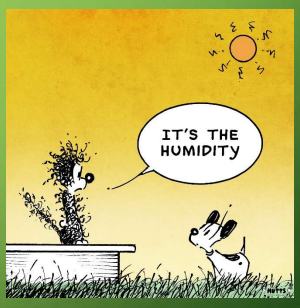
FILM BADGE DISADVANTAGES

- 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 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 is 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
- 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-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

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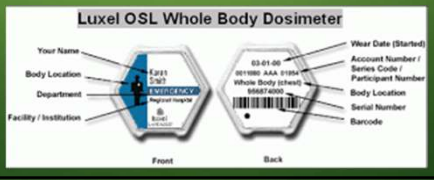
OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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 it's worn
- 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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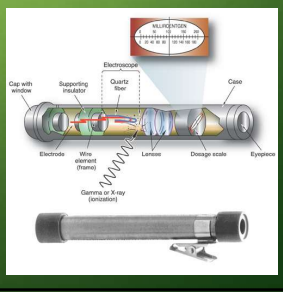
POCKET IONIZATION CHAMBER

- 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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

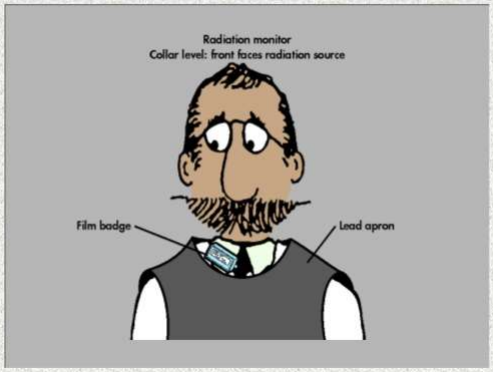
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

Occupational radiation monitor does NOT protect against radiation exposure!



27

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

28

REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

29

READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP TESTING
NVLAP LAB CODE 100518-0

LANDAUER®
LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

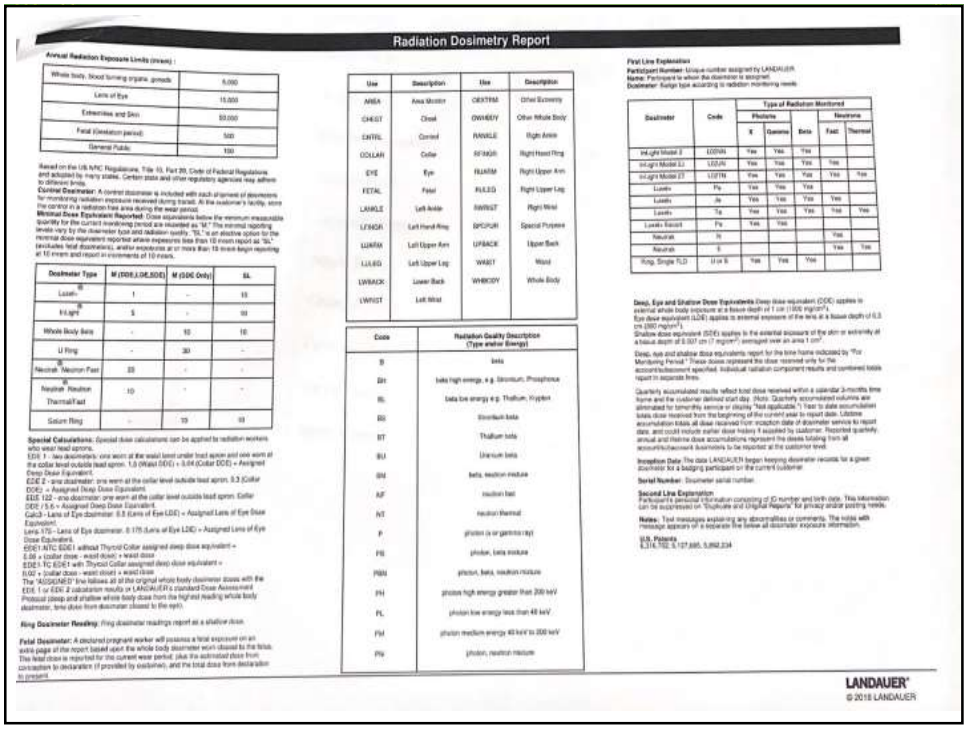
Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

30



Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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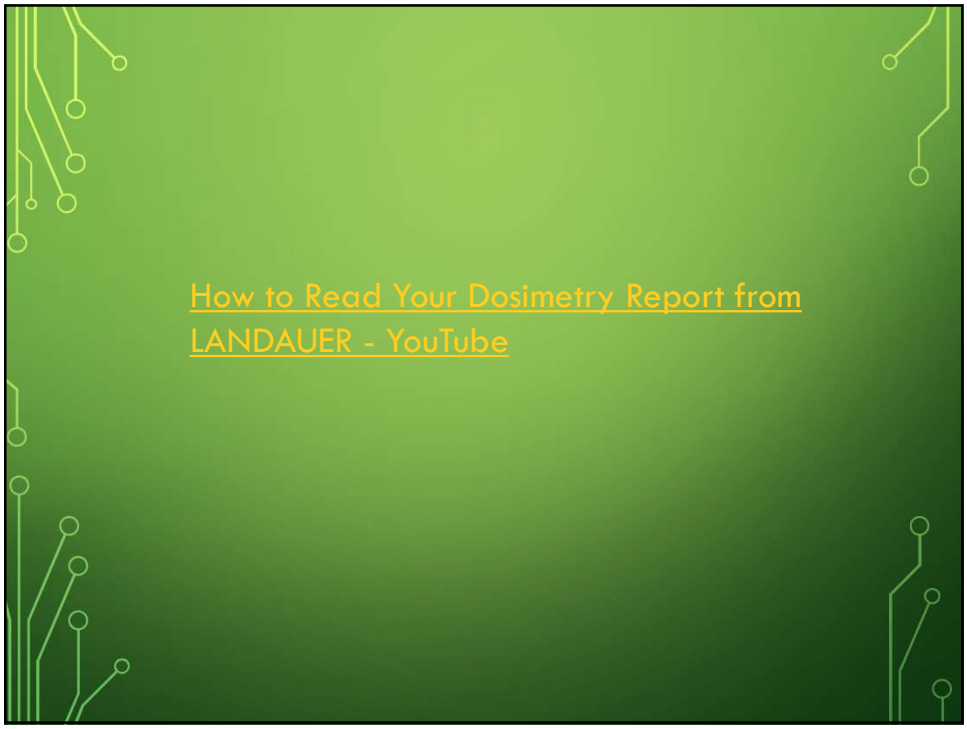

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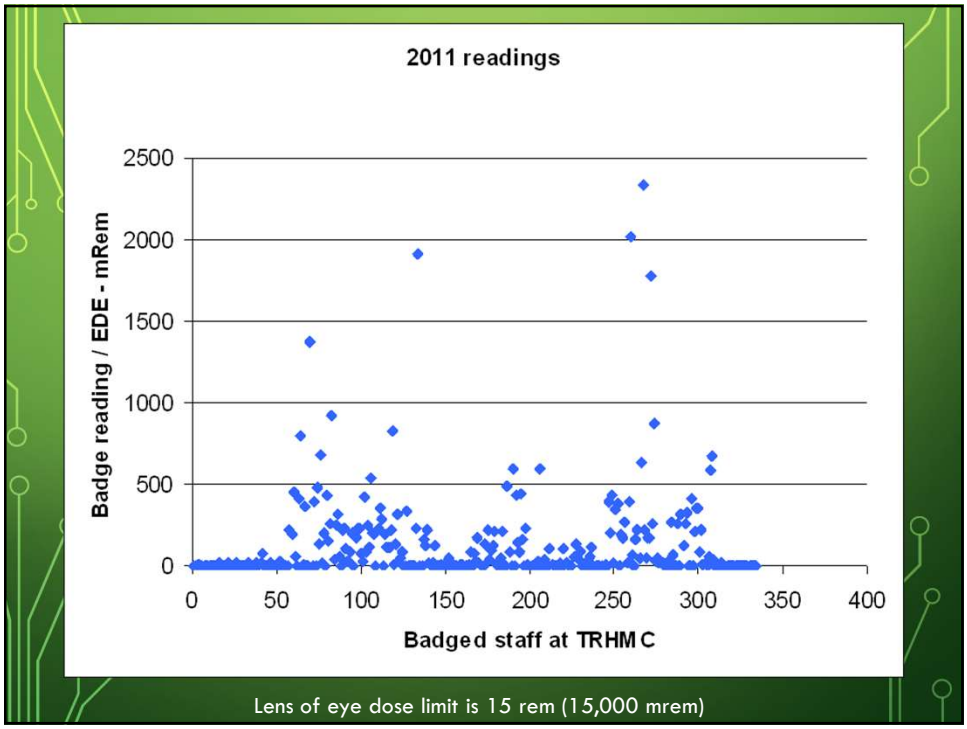
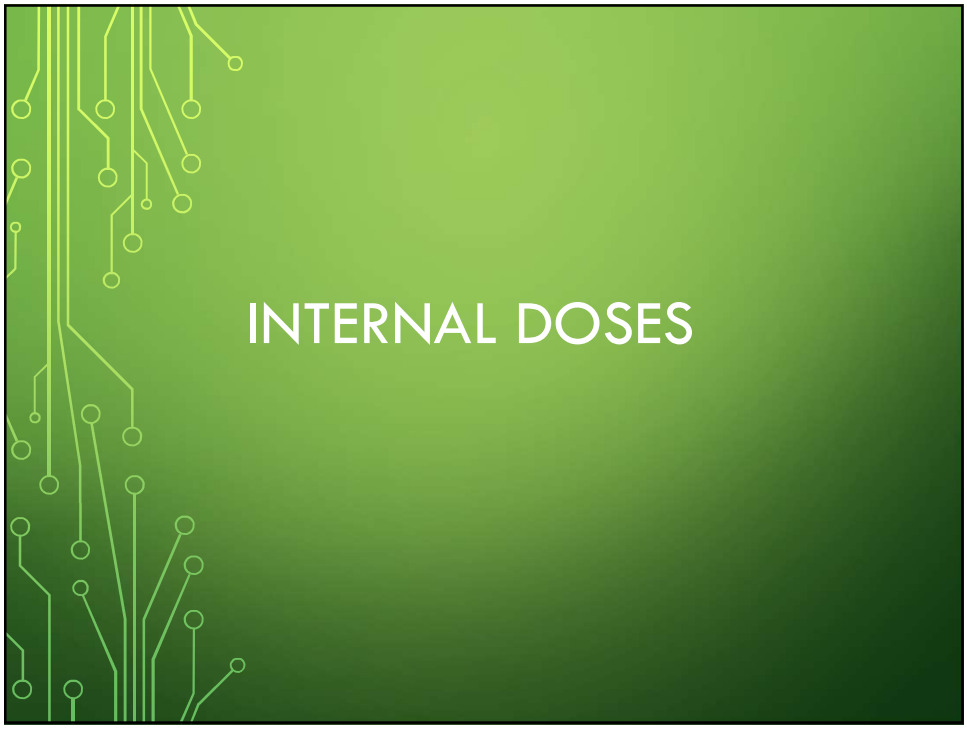

2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

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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

From NCRP 160

35

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

36

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…..

37

RADIATION SURVEYS INSTRUMENTS

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

38

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 INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

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"CUTIE PIE"

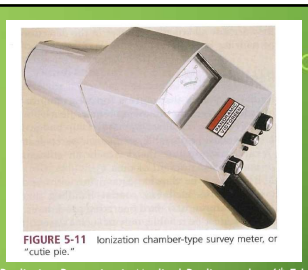

FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

42

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

43

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

45

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%

46

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

47

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

48

REVIEW QUESTIONS

49

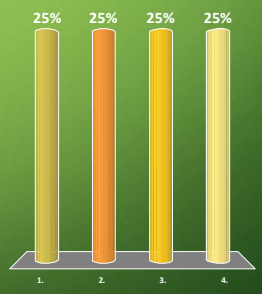
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

50

WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



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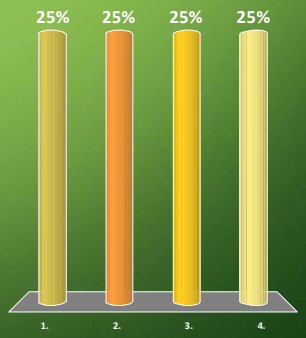
WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

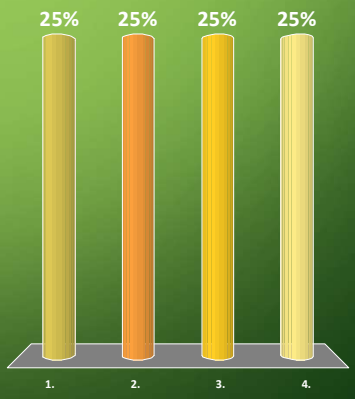
1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



52

WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



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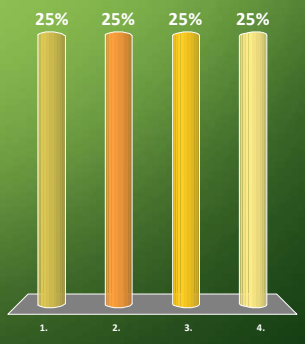
WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

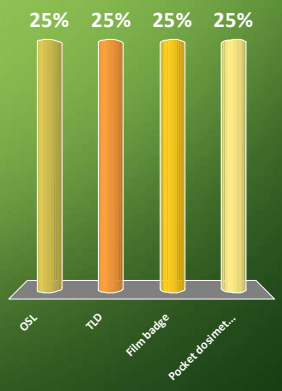
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



55

WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

56

57

Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)

MI 120 Ch. 5 Summer 2022

1

- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

2

REQUIREMENTS FOR PERSONNEL

- Personnel dosimetry monitors the equivalent dose to any person occupationally exposed on a regular basis to ionizing radiation
- 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 (As Low As Reasonably Achievable) concept, most facilities issue devices when personnel might receive 1% of that dose

3

PURPOSE OF PERSONNEL DOSIMETERS

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

4

PLACEMENT

- During diagnostic radiology, the badge should be worn at collar level facing forward 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

5

CONTROL BADGES

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

6

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

https://www.plmedical.com/index.php/faqs/

7

MONITOR CHARACTERISTICS

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

8

TYPES OF PERSONNEL MONITORING

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

9

FILM BADGE

- Not used as often
- Records whole body radiation at low rate over a long period of time
- Uses dental film
- Filters low energy x-ray, gamma and beta
- Has aluminum and copper filters that allow conversion to tissue dose

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

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

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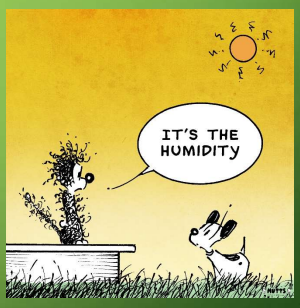
FILM BADGE ADVANTAGES

- Cost efficient
  - A few dollars a month
- Provides permanent, legal record
- Detects different types of radiation and can discriminate between types
- Measures as low as 0.1mGy
  - Doses below that are recorded as minimal
- Durable if dropped
- Can determine if exposure is from scatter or primary radiation

11

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 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

13

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

14

TLD DISADVANTAGES

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

15

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Best features of film badge and TLD
- Detector is aluminum oxide
- 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

16

OSL-
OPTICALLY STIMULATED LUMINESCENT DOSIMETER

- Most common type of device used to monitor occupational exposure
- Best features of film badge and TLD
- Contains aluminum oxide layer
- Contains 3 filters:
  - aluminum (least absorption, shallow)
  - tin (eye)
  - copper (most absorption, deep)

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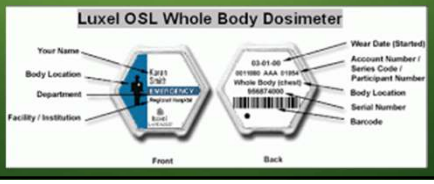
OSL ADVANTAGES

- Lightweight, durable and easy to carry & wear
- 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



18

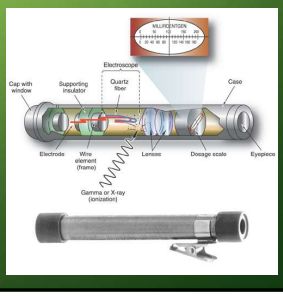
OSL DISADVANTAGES

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

19

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)



20

POCKET IONIZATION CHAMBER ADVANTAGES

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

FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of the self-reading pocket dosimeter generally used in radiology indicates exposures of 0 to 5.2×10^{-4} C/kg (0 to 200 mR). Before being used, each pocket dosimeter should be charged to a predetermined voltage by a special charging unit (**B**) so that the charges of the positive and negative electrodes are balanced and the quartz fiber indicator reads zero (0).

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

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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

22

DIRECT ION STORAGE DOSIMETER (DIS)

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

Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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DIRECT ION STORAGE DOSIMETER ADVANTAGES

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

24

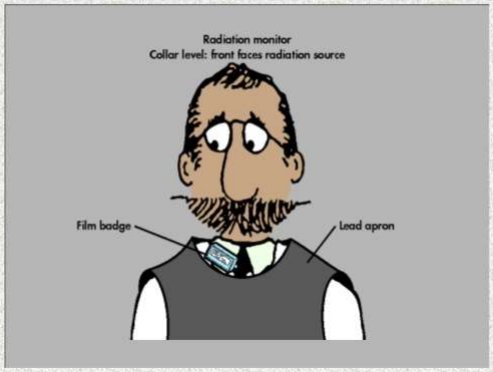
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

25

26

Occupational radiation monitor does NOT protect against radiation exposure!



27

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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REQUIREMENTS OF PERSONNEL MONITORING

- Timeframes
  - Period of time wearing (monthly for RH)
  - Quarterly
  - Yearly
  - Lifetime
- Doses
  - Deep dose equivalent- DDE
    - 1cm depth in soft tissue
    - Absorbed dose
  - Shallow dose equivalent- SDE
    - 0.007cm depth in soft tissue
    - Dose to external skin
  - Eye or Lens dose equivalent- EDE or LDE
    - 0.3cm depth in the eye
    - Exposure to the lens

29

READING HOSPITAL
ATTN: CHANDRA KOTA
PO BOX 16052
READING, PA 19612-6052

Received Date / Reported Date	2022-03-18 / 2022-03-25
Page	1 of 3
Analytical Work Order / QC Release	2207700129 / LCA
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NVLAP TESTING
NVLAP LAB CODE 100518-0

LANDAUER®
LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8830
Technical: (800) 438-3241

Radiation Dosimetry Report

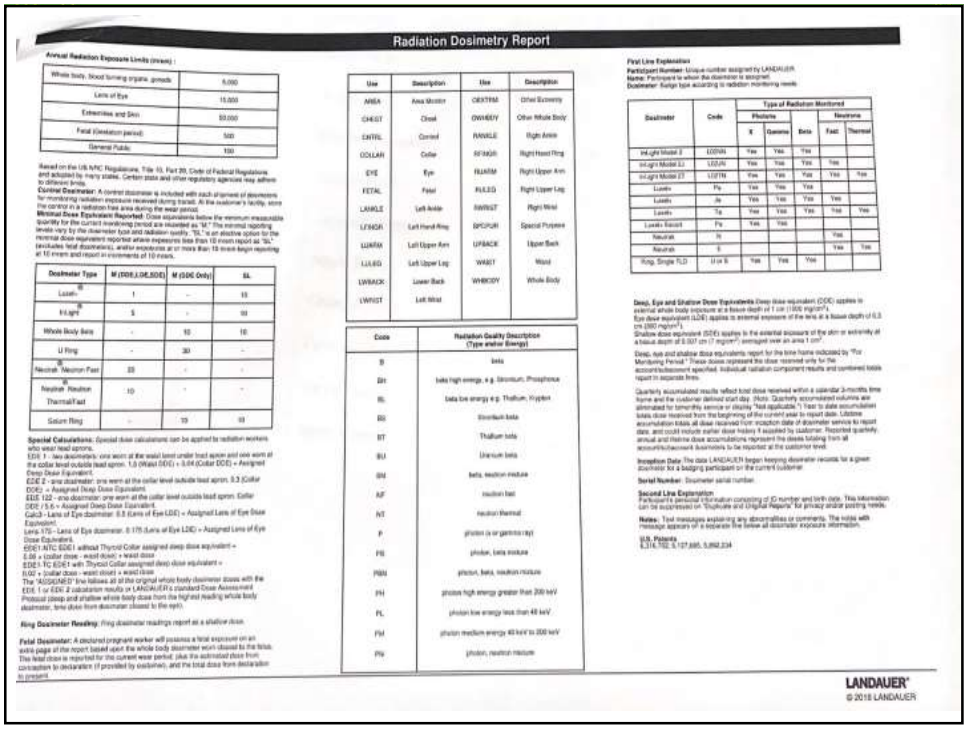
Account : 719 baccount: 1456718 Series: SHS

**No NVLAP accreditation is available from NVLAP for thermal neutron or X type dosimeters. When exposure results are reported for thermal neutrons or X type dosimeters, this report contains data that are not covered by the NVLAP accreditation.

Participant Number	Name / ID Number / Birth Date	Dosimeter	Use	Rad. Type	Rad. Quality	Dose Equivalent (mrem) for Periods Shown Below — DDE-Deep Dose Equivalent LDE-Lens Dose Equivalent SDE-Shallow Dose Equivalent												Inception Date	Serial Number
						Period Shown Below			Quarter to Date			Year to Date			Lifetime to Date				
						DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE		
For Monitoring Period:						2022-02-01 to 2022-02-28			QUARTER 1			2022			LIFETIME				
00SHS	CONTROL Control Dose Used	Pa Pa	CNTRL			13	13	13											9975483L
00639		Pa	COLLAR			M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641		Pa	COLLAR			M	M	M	M	M	M	M	M	M	139	157	156	2018/01	9975485L
00712		Pa	COLLAR			M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00714		Pa	COLLAR			M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00720		Pa	COLLAR			M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00725		Pa	COLLAR			M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													
00737		Pa	COLLAR			M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L
			ASSIGNED NOTE			M	M	M	M	M	M	M	M	M					
						Assigned dose based on EDE2 Calculation													

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

30



Radiation Dosimetry Report

Annual Radiation Exposure Limits (mrem) :

Whole body, blood forming organs, gonads	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Gestation period)	500
General Public	100

Based on the US NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may adhere to different limits.

Control Dosimeter: A control dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during transit. At the customer's facility, store the control in a radiation free area during the wear period.

Minimal Dose Equivalent Reported: Dose equivalents below the minimum measurable quantity for the current monitoring period are recorded as "M." The minimal reporting levels vary by the dosimeter type and radiation quality. "SL" is an elective option for the minimal dose equivalent reported where exposures less than 10 mrem report as "SL" (excludes fetal dosimeters), and/or exposures at or more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DDE),(LDE,SDE)	M (DDE Only)	SL
Luxel+	1	-	10
InLight	5	-	10
Whole Body Beta	-	10	10
U Ring	-	30	-
Neutrak Neutron Fast	20	-	-
Neutrak Neutron Thermal/Fast	10	-	-
Saturn Ring	-	10	10

Special Calculations: Special dose calculations can be applied to radiation workers who wear lead aprons.
EDE 1 - two dosimeters: one worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.5 (Waist DDE) + 0.04 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 2 - one dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Deep Dose Equivalent.
EDE 122 - one dosimeter: one worn at the collar level outside lead apron. Collar DDE / 5.6 = Assigned Deep Dose Equivalent.
Ga(3 - Lens of Eye dosimeter. 0.3 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
Lens 175 - Lens of Eye dosimeter. 0.175 (Lens of Eye LDE) = Assigned Lens of Eye Dose Equivalent.
EDE1 NTC EDE1 without Thyroid Collar assigned deep dose equivalent =
0.06 x (collar dose - waist dose) + waist dose
EDE1 TC EDE1 with Thyroid Collar assigned deep dose equivalent =
0.02 x (collar dose - waist dose) + waist dose
The "ASSIGNED" line follows all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calculation results or LANDAUER's standard Dose Assessment Protocol (deep and shallow whole body dose from the highest reading whole body dosimeter, lens dose from dosimeter closest to the eye).

Ring Dosimeter Reading: Ring dosimeter readings report as a shallow dose.

Fetal Dosimeter: A declared pregnant worker will possess a fetal exposure on an extra page of the report based upon the whole body dosimeter worn closest to the fetus. This fetal dose is reported for the current wear period, plus the estimated dose from conception to declaration (if provided by customer), and the total dose from declaration to present.

Use	Description	Use	Description
AREA	Area Monitor	OEXTRM	Other Extremity
CHEST	Chest	OWHBDY	Other Whole Body
CNTRL	Control	RANKLE	Right Ankle
COLLAR	Collar	RFARM	Right Hand Ring
EYE	Eye	RUARM	Right Upper Arm
FETAL	Fetal	RULEG	Right Upper Leg
LANKLE	Left Ankle	RWRST	Right Wrist
LFNGR	Left Hand Ring	SPCPUR	Special Purpose
LUARM	Left Upper Arm	UPBACK	Upper Back
LULEG	Left Upper Leg	WAIST	Waist
LWBACK	Lower Back	WHBODY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and/or Energy)
B	beta
BH	beta high energy, e.g. Strontium, Phosphorus
BL	beta low energy e.g. Thallium, Krypton
BS	Strontium beta
BT	Thallium beta
BU	Uranium beta
BM	beta, neutron mixture
NF	neutron fast
NT	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photons high energy greater than 200 keV
PL	photon low energy less than 48 keV
PM	photon medium energy 48 keV to 200 keV
PN	photon, neutron mixture

Final Line Explanation
Participant Number: Unique number assigned by LANDAUER.
Name: Participant to whom the dosimeter is assigned.
Dosimeter: Badge type according to radiation monitoring needs.

Dosimeter	Code	Type of Radiation Monitored				
		Photons			Neutrons	
		X	Gamma	Beta	Fast	Thermal
InLight Model 2	LDTIN	Yes	Yes	Yes		
InLight Model 21	LD2JN	Yes	Yes	Yes	Yes	
InLight Model 27	LDFTN	Yes	Yes	Yes	Yes	Yes
Luxel+	Fp	Yes	Yes	Yes		
Luxel+	Ar	Yes	Yes	Yes	Yes	
Luxel+	Ta	Yes	Yes	Yes	Yes	Yes
Luxel+ Result	Fp	Yes	Yes			
Neutrak	N				Yes	
Neutrak	B				Yes	Yes
Ring, Single TLD	U or S	Yes	Yes	Yes		

Deep, Eye and Shallow Dose Equivalents Deep dose equivalent (DDE) applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm²).
Eye dose equivalent (LDE) applies to external exposure of the lens at a tissue depth of 0.3 cm (300 mg/cm²).
Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a tissue depth of 0.007 cm (7 mg/cm²), averaged over an area 1 cm².

Deep, eye and shallow dose equivalents report for the time frame indicated by "For Monitoring Period." These doses represent the dose received only for the account/subaccount specified. Individual radiation component results and combined totals report in separate lines.

Quarterly accumulated results reflect total dose received within a calendar 3-months time frame and the customer defined start day. (Note: Quarterly accumulated columns are eliminated for bimonthly service or display "Not applicable.") Year to date accumulation totals dose received from the beginning of the current year to report date. Lifetime accumulation totals all dose received from inception date of dosimeter service to report date, and could include earlier dose history if supplied by customer. Reported quarterly, annual and lifetime dose accumulations represent the doses totaling from all account/subaccount dosimeters to be reported at the customer level.

Inception Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badging participant on the current customer.

Serial Number: Dosimeter serial number.

Second Line Explanation
Participant's personal information consisting of ID number and birth date. This information can be suppressed on "Duplicate and Original Reports" for privacy and/or posting needs.

Notes: Text messages explaining any abnormalities or comments. The notes with message appears on a separate line below all dosimeter exposure information.

U.S. Patents
6,314,702; 6,127,685; 5,962,334

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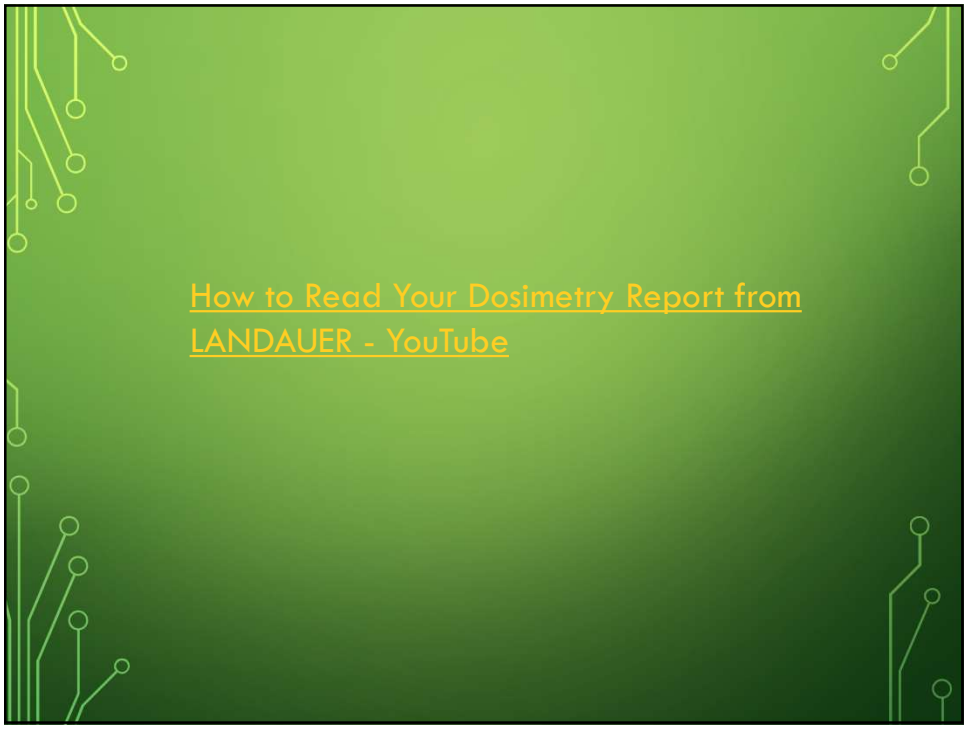

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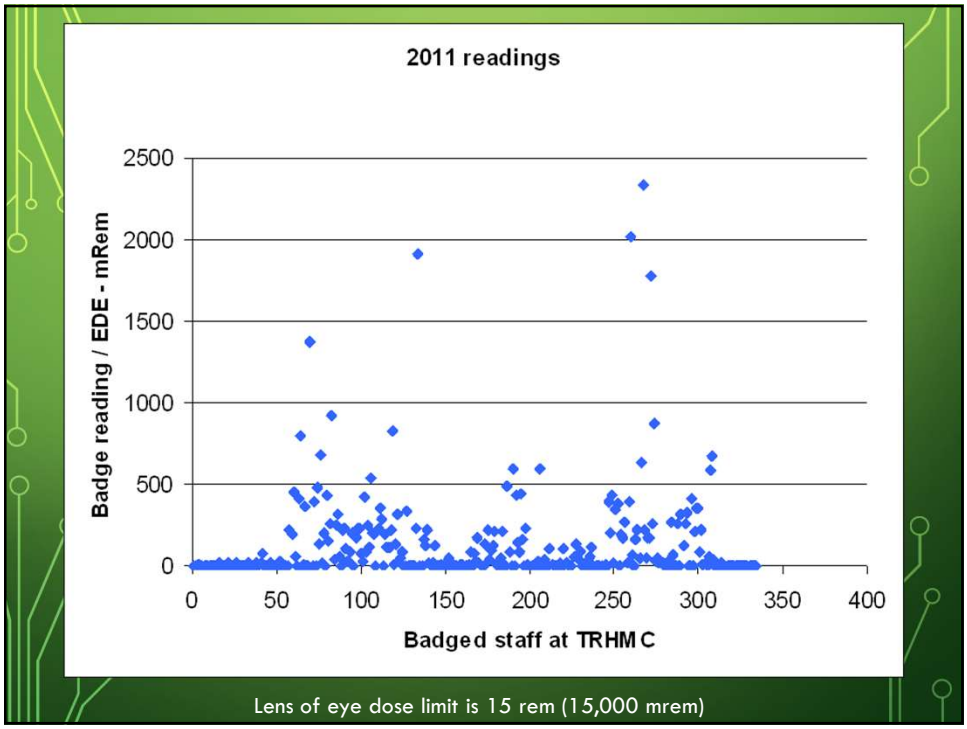
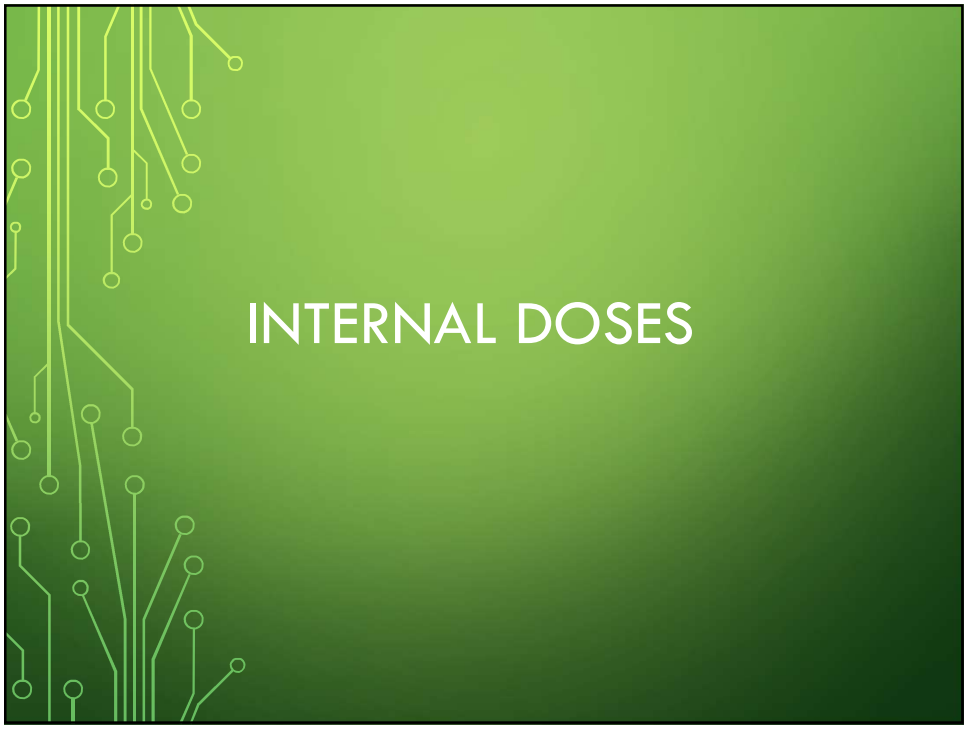

2011 readings
Badge reading / EDE - mRem
2500
2000
1500
1000
500
0
0
50
100
150
200
250
300
350
400
Badged staff at TRHMC
Lens of eye dose limit is 15 rem (15,000 mrem)

33


INTERNAL DOSES

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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

From NCRP 160

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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

38

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 INSTRUMENTS

- Ionization chamber "cutie pie"
- Proportional counter
- Geiger Muller (G-M) detector

40

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 patients with radioactive sources
- Can be used to measure doses traveling through barriers

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"CUTIE PIE"

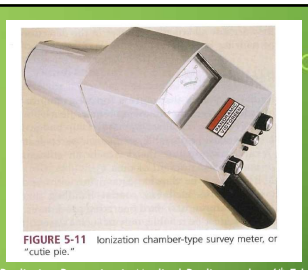

FIGURE 5-11 Ionization chamber-type survey meter, or "cutie pie."

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

- Advantages
  - Measures a wide range of exposures in a few seconds
  - Can be used to calibrate x-ray equipment
- Disadvantages
  - Without adequate warm up, could cause inaccurate readings
  - Large size
  - Delicate construction
  - Not good with short exposure times

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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

45

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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REVIEW QUESTIONS

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WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose

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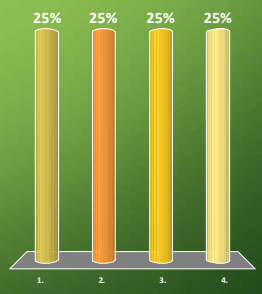
WHAT TYPE OF PERSONNEL MONITORING DEVICE DO WE UTILIZE DAILY AT RH?

1. TLD
2. OSL
3. Film badge
4. Pocket dosimeter



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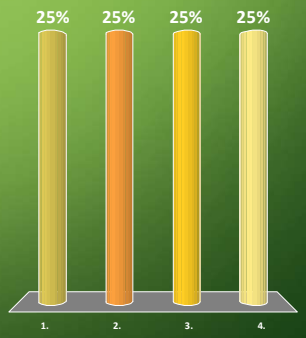
WHERE CAN YOU LOCATE YOUR DEEP, SHALLOW AND EYE DOSE LEVELS?

1. Compliance report
2. Quality assurance report
3. Yearly evaluation
4. Personnel monitoring report



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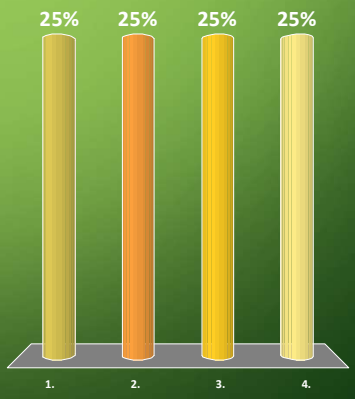
WHICH SURVEY INSTRUMENT IS USED TO LOCATE RADIOACTIVE MATERIALS IN NM?

1. TLD
2. Cutie pie
3. GM counter
4. Proportional counter



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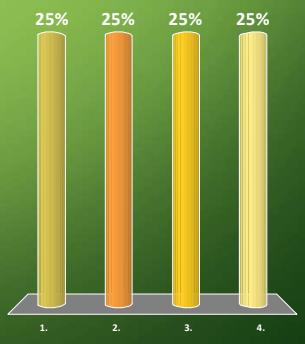
WHICH OF THE FOLLOWING TIMEFRAMES IS NOT INCLUDED ON THE DOSE REPORT?

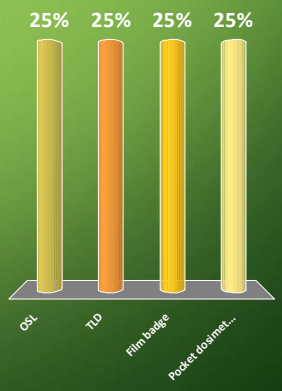
1. Daily
2. Monthly
3. Quarterly
4. Yearly



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

1. OSL
2. TLD
3. Film badge
4. Pocket dosimeter



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WHAT IS THE SENSING MATERIAL IN A TLD?

1. Barium sulfate
2. Calcium tungstate
3. Lithium fluoride
4. Sodium iodide

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