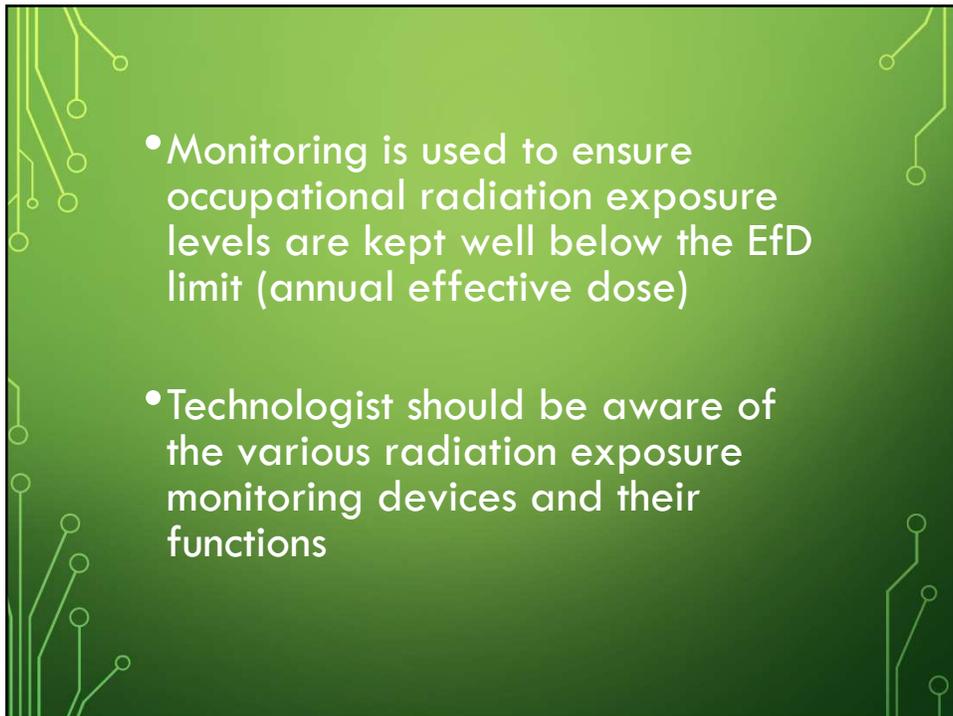


Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

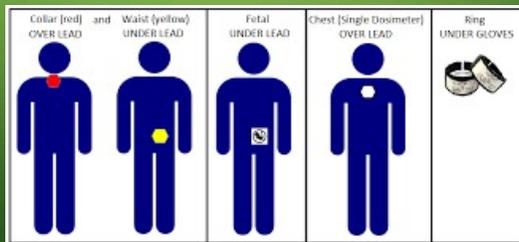


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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 0.1 mGy
 - 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 to be sent out to be read



12

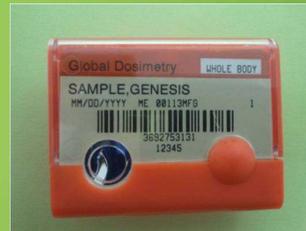
TLD- THERMOLUMINESCENT DOSIMETER

- 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 if not carefully recorded because once energy is released from crystals it cannot be reread
- Records only exposure to area in which it is worn



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



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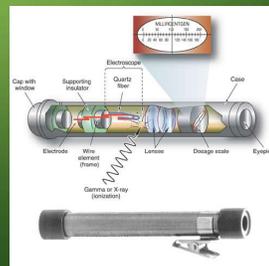
OSL DISADVANTAGES

- 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

19

POCKET IONIZATION CHAMBER

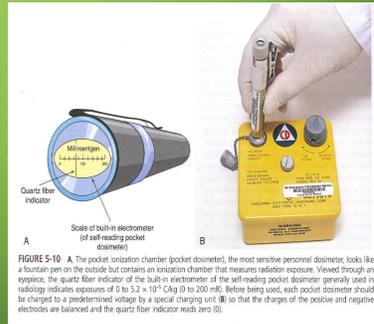
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



20

POCKET IONIZATION CHAMBER ADVANTAGES

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



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

21

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

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	Range Type 1	Range Type 2	Range Type 3	Range Type 4	Range Type 5 (LUMC & R-22) (MCP or LR 115)	Range Type 6	Range Type 7	
Personal Dosimeters	Instadose®2	Instadose®3	Instadose®4	APex™	Genesis Ultra TLD™	Measuring™	Ultra™ & Flex™	
Overview	All the advantages reported of traditional TLDs with measurement for both radon and gamma.	Instadose enables repetitive weekly, biweekly, or monthly dose rate, region, work, reporting.	The only available ODS compatible dosimeter available for use in occupational dose measurement.	After dosimeter can be re-used multiple times, enabling an individual into several exposures.	Ultra Ultra TLD dosimeters, Genesis Ultra TLD also measured total exposure with weekly or biweekly.	Range and frequency dosimeters are ideal for low or high energy beta, X-ray or gamma radon monitoring of hands and fingers.		
Features	• Dose rate and region measurement of dose work on mobile smart devices, Instadose 2 (NIST or Instadose™ ODS) NIST certified calibration process. • Hands-free online reporting. • Identical, on demand dose work. • Biweekly, job-site calibration, dose work.	• Biweekly online measurement of dose work on mobile smart devices, Instadose 3 (NIST or Instadose™ ODS) NIST certified calibration process. • Hands-free online reporting. • Identical, on demand dose work. • Biweekly, job-site calibration, dose work.	• Traditional dose work. • Dose rate badge collection and calibration process. • Hands-free online reporting. • Regional compliance.	• Reusable dosimeter for use in occupational and training. • Works both, dose monitoring. • Reusable, up to 1000 cycles. • Flexible, they can be used in various settings, such as in occupational or training.	• New generation of TLDs in form of ultra ultra and training. • Works both, dose monitoring. • Reusable, up to 1000 cycles. • Flexible, they can be used in various settings, such as in occupational or training.	• New generation of TLDs in form of ultra ultra and training. • Works both, dose monitoring. • Reusable, up to 1000 cycles. • Flexible, they can be used in various settings, such as in occupational or training.	• Individually calibrated. • Available in 4 sizes. • Can be measured in water and used for monitoring of hands and fingers. • Ultra Ultra TLD dosimeters with online (dose work). • Ultra Ultra TLD dosimeters with online (dose work).	• Ultra Ultra TLD dosimeters with online (dose work). • Ultra Ultra TLD dosimeters with online (dose work).
Applications	Requires primarily exposed to occupational radionuclides. Can also be used for area monitoring.	Requires primarily exposed to occupational radionuclides. Can also be used for area monitoring.	Requires primarily exposed to occupational radionuclides. Can also be used for area monitoring.	Requires primarily exposed to occupational radionuclides. Can also be used for area monitoring.	Requires primarily exposed to occupational radionuclides. Can also be used for area monitoring.	Individuals handling radionuclides, performing environmental radiographic procedures, or who have higher risk of radionuclide exposure to their hands and fingers.		
Description	Instadose 2 (NIST or Instadose™ ODS) NIST certified calibration process.	Instadose 3 (NIST or Instadose™ ODS) NIST certified calibration process.	Instadose 4 (NIST or Instadose™ ODS) NIST certified calibration process.	Instadose 4 (NIST or Instadose™ ODS) NIST certified calibration process.	Instadose 4 (NIST or Instadose™ ODS) NIST certified calibration process.	Instadose 4 (NIST or Instadose™ ODS) NIST certified calibration process.	Instadose 4 (NIST or Instadose™ ODS) NIST certified calibration process.	
Min. Reportable Dose (MRD) & Useful Dose Range	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	0.05 mSv (500 µSv) to 100 mSv (10,000 µSv)	
Energy Response	Photo 1 keV - 6 MeV Beta 0.01 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	
Accreditations	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)	US NIST (NIST code 100000-0) NIST (NIST code 100000-0) NIST (NIST code 100000-0)
Holder Type Prog. size and measurement and response.								

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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	2287700129 / LCA
Copy / Version	0 / 1



NVLAP LAB CODE 105518-0

LANDAUER[®]
 LANDAUER, Inc., 2 Science Road
 Glenwood, Illinois 60425-1586
 landauer.com
 Telephone: (708) 755-7000
 Facsimile: (708) 755-7016
 Customer Service: (800) 323-8850
 Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 Account: 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	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									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: 2022-03-01 to 2023-02-28								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9975485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
00714	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
00720	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
00725	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
00737	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L

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 (mSv)

Whole Body, Most Sensitive Organs, Adults	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Pregnant female)	500
General Public	100

Based on the 10 NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may address or otherwise limit.

Dosimeter Description: A dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during work. At the customer's facility, when the dosimeter is in a radiation-free area during the work period.

Minimal Dose Equivalent Reported: Dose measurements below the minimal measurable quantity for the current monitoring period are reported as "0". The minimal reporting level may vary by the dosimeter type and radiation quality. "0" can also mean "up to" the minimal dose equivalent reported when exposures are less than 10 mrem report as "0". Includes total dose equivalent, and/or exposures of more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (Dose Equivalent)	M (Dose Only)	SL
Lead	1	-	10
Ring	5	-	50
Whole Body	-	10	10
Li Ring	-	30	-
Neutron Monitor/Facet	10	-	-
Neutron Monitor/Thermal/Facet	10	-	-
Skin Ring	-	10	10

Special Considerations: Dosimeter calibration can be applied by radiation workers who wear lead aprons.
 EDE 1 - Two dosimeters are worn at the waist level under lead apron and one worn at the collar level outside lead apron. 1.0 (Mantle DDE) + 0.04 (Collar DDE) = Assigned Dose Equivalent.
 EDE 2 - One dosimeter is worn at the collar level outside lead apron. 0.3 Collar DDE = Assigned Dose Equivalent.
 EDE 12 - One dosimeter is worn at the collar level outside lead apron. Collar DDE 12 = Assigned Dose Equivalent.
 Collar - Lens of Eye Dosimeter: 0.3 Lens of Eye DDE = Assigned Lens of Eye Dose Equivalent.
 Lens 175 - Lens of Eye Dosimeter: 0.175 Lens of Eye DDE = Assigned Lens of Eye Dose Equivalent.
 EDE 175 - EDE 175 without Thyroid Collar assigned dose equivalent = 0.06 + collar dose + waist dose + wrist dose.
 EDE 175 EDE 175 with Thyroid Collar assigned dose equivalent = 0.02 + collar dose + wrist dose + waist dose + wrist dose.
 The ASSOCIATED tag below all of the original whole body dosimeter doses with the EDE 1 or EDE 2 calibration results in LANDAUER's standard Dose Assessment Protocol group and studies whole body dose from the highest reading whole body dosimeter, less than from dosimeter located to the eye).

Ring Dosimeter Readings: Ring dosimeter readings report as a shallow dose.
Fetal Dosimeter: A dosimeter program marker will assume a fetal exposure on all data pages of the report. Contact your local body dosimeter agent to obtain the fetal dose. The fetal dose is reported for the current work period. Also the estimated dose from conception to dosimeter (if provided by customer), and the total dose from conception to present.

Use	Description	Use	Description
AREA	Area Monitor	CELEST	Celex Economy
CHGRT	Cloud	DW66EV	Other Whole Body
CTRL	Control	RSGLC	Right Arm
COLLAR	Collar	AF95U	Right Hand/Thng
EYE	Eye	HEAMR	Right Upper Arm
FETAL	Fetal	FLLED	Right Upper Leg
LEADLE	Lead Shield	BM95G	Right Hand
LFRM	Left Hand Ring	DFCPH	Special Purpose
LURM	Left Upper Arm	DFBAC	Upper Back
LULG	Left Upper Leg	WABT	Waist
LWBAC	Lower Back	WBWDY	Whole Body
LWIST	Left Wrist		

Code	Radiation Quality Description (Type and Energy)
B	beta
BI	beta high energy, e.g. Barium, Protactinium
BL	beta low energy, e.g. Thallium, Tritium
BS	bremsstrahlung
BT	Thallium beta
BU	Uranium beta
BU	beta, neutron mixture
DF	neutron fast
DF	neutron thermal
F	photon (x or gamma ray)
FB	photon, beta mixture
FBM	photon, beta, neutron mixture
PH	photon high energy greater than 200 keV
PL	photon low energy less than 40 keV
PH	photon medium energy 40 keV to 200 keV
PH	photon, neutron mixture

First 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	Fast	Thermal	Other
FL-Right Hand 1	10294	Yes	Yes	Yes	Yes	
FL-Right Hand 2	10295	Yes	Yes	Yes	Yes	
FL-Right Hand 3	10296	Yes	Yes	Yes	Yes	
Lead	06	Yes	Yes	Yes	Yes	
Lead	7a	Yes	Yes	Yes	Yes	
Lead	7b	Yes	Yes	Yes	Yes	
Lead	7c	Yes	Yes	Yes	Yes	
Neutron	10					Yes
Neutron	8					Yes
Ring, Single FL2	174 0 0	Yes	Yes	Yes	Yes	

Dose, Eye and Shallow Dose Equivalents: Deep dose equivalent (DDE) applies to external whole body exposure at a dose depth of 1 cm (3000 mg/cm²). Eye dose equivalent (EDE) applies to external exposure of the lens at a dose depth of 0.3 cm (300 mg/cm²). Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a dose depth of 0.007 cm (7 mg/cm²) averaged over an area 1 cm².

Dose, Eye and Shallow Dose Equivalent Report: The dose from radiation for the time frame indicated by the Monitoring Period. These doses represent the dose received only to the measurement specified. Individual radiation component results and combined totals report in separate form.

Quarterly Accumulated Results: Report whole body dose received within a calendar 3-month time frame and the customer defined start day. Data: Quarterly accumulated results are generated for quarterly service or display. Not applicable. Year to date equivalent beta dose received from the beginning of the current year to report date. Lifetime accumulated beta dose received from inception date of dosimeter service to report date, and total include entire dose history if available to customer. Reported quarterly annual and lifetime dose accumulations represent the beta dosimeter beta M rem/100mrem/100mrem to be reported at the customer level.

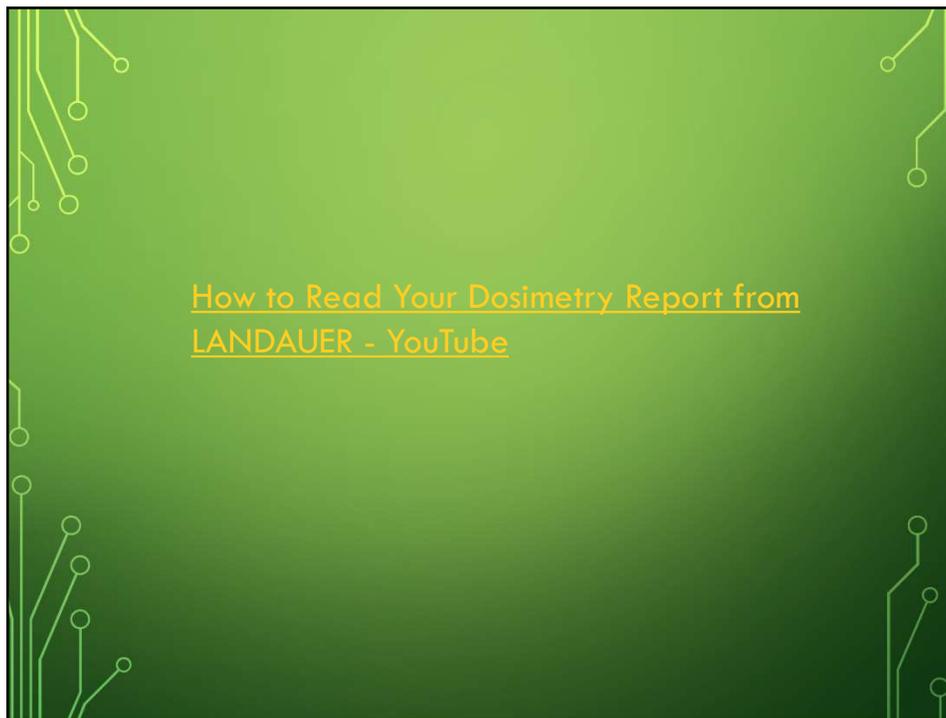
Receipt Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badge purchased on the current customer.

Serial Number: Dosimeter part number.

Second Line Explanation
 Participant Number: Unique number consisting of ID number and birth date. This information can be represented on "Thumbnail and Single Report" for privacy and/or pending needs.
Name: Text message explaining any abnormalities or concerns. This tag with telephone operators of a telephone line below all dosimeter exposure information.

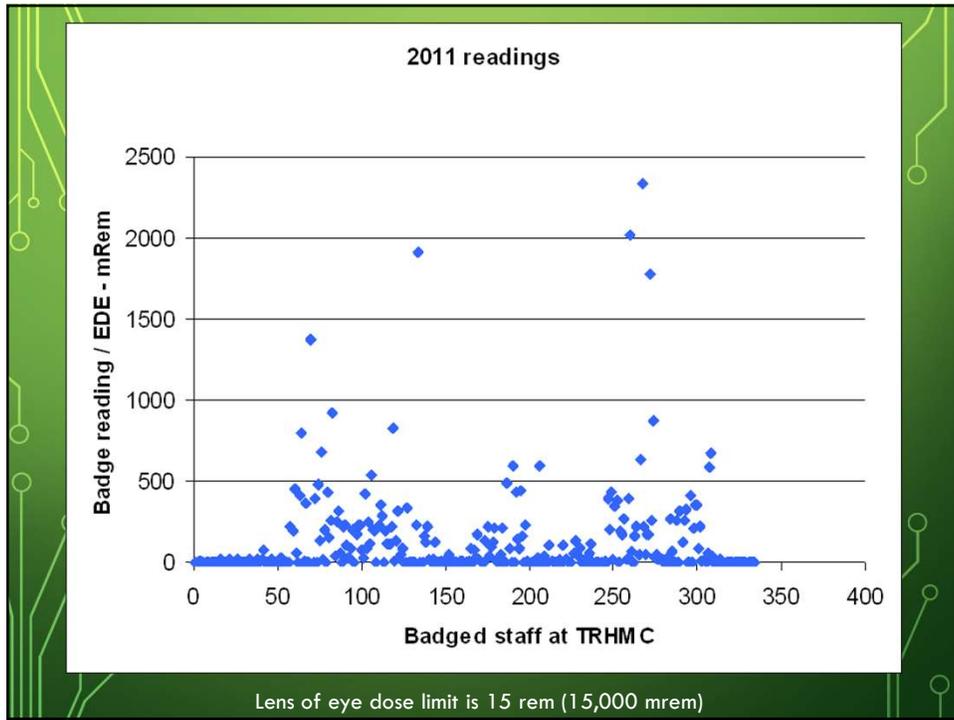
SL, Patient:
 0118, 700, 3, 127, 885, 3,892, 238

31

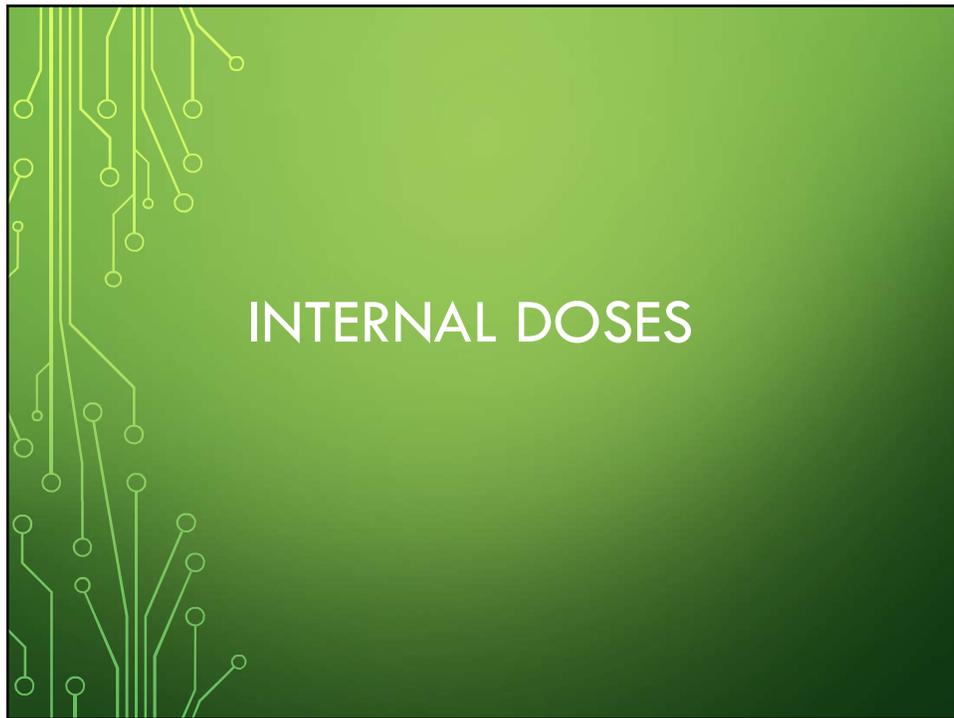


How to Read Your Dosimetry Report from LANDAUER - YouTube

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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

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

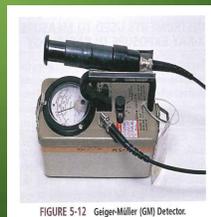


FIGURE 5-12 Geiger-Müller (GM) Detector.

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



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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%



46

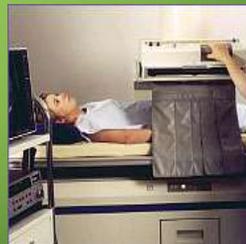
EQUIPMENT SURVEYS

- 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



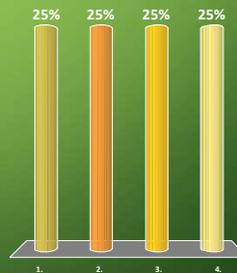
48

REVIEW QUESTIONS

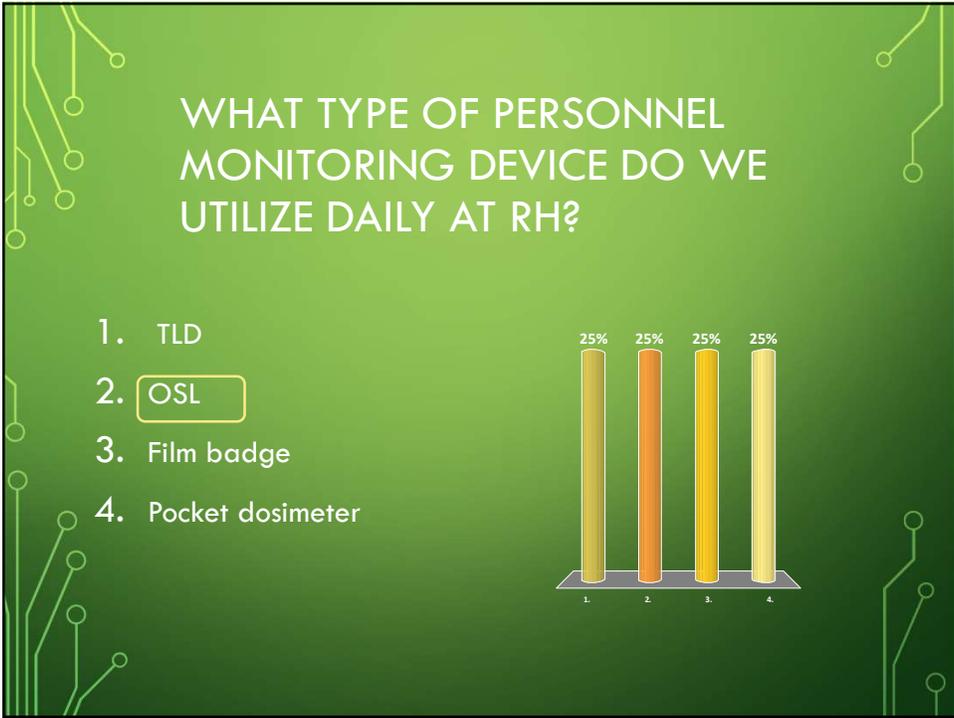
49

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

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



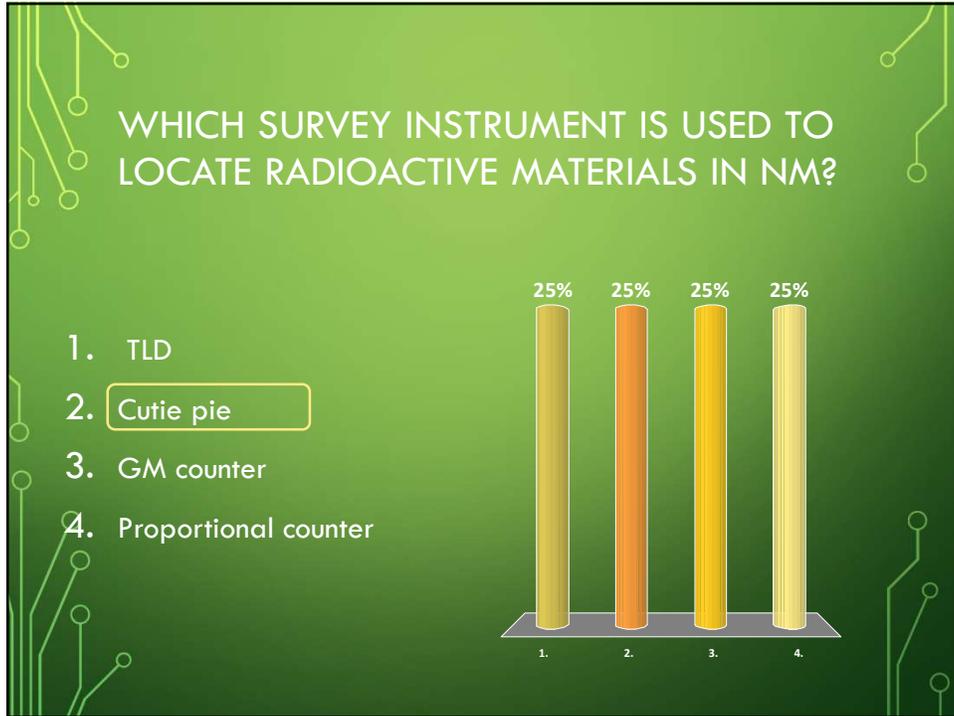
50



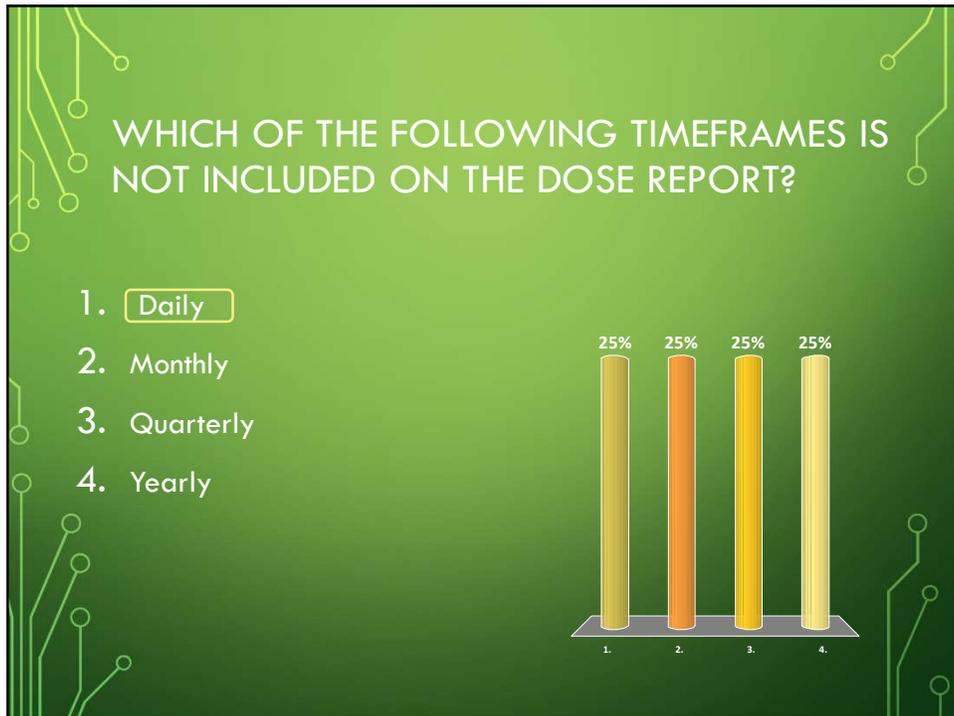
51



52



53



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

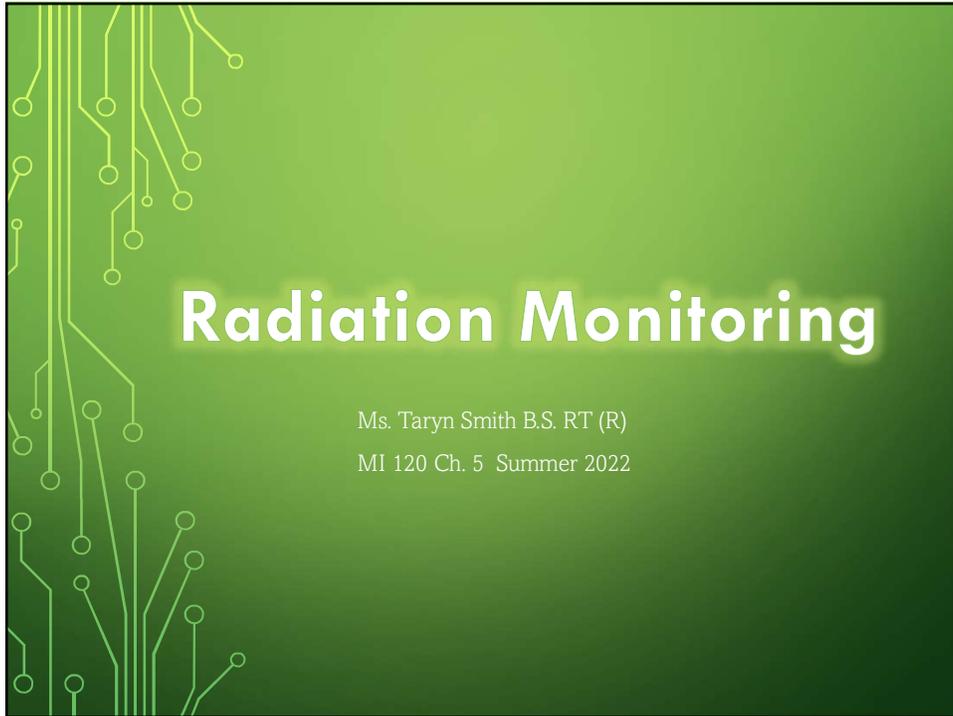
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

56



57



Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

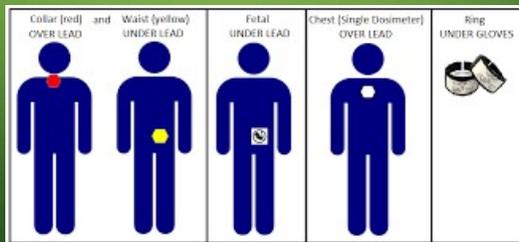


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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 0.1 mGy
 - 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 to be sent out to be read



12

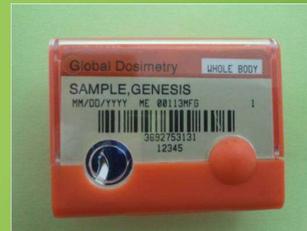
TLD- THERMOLUMINESCENT DOSIMETER

- 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 if not carefully recorded because once energy is released from crystals it cannot be reread
- Records only exposure to area in which it is worn



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

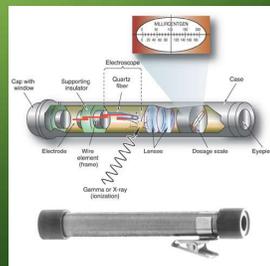
OSL DISADVANTAGES

- 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

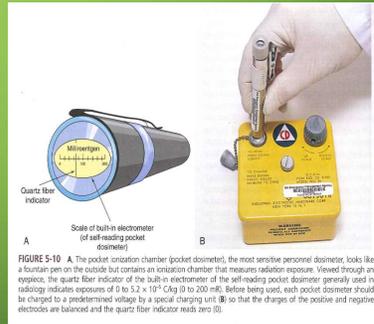
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



20

POCKET IONIZATION CHAMBER ADVANTAGES

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



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

21

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



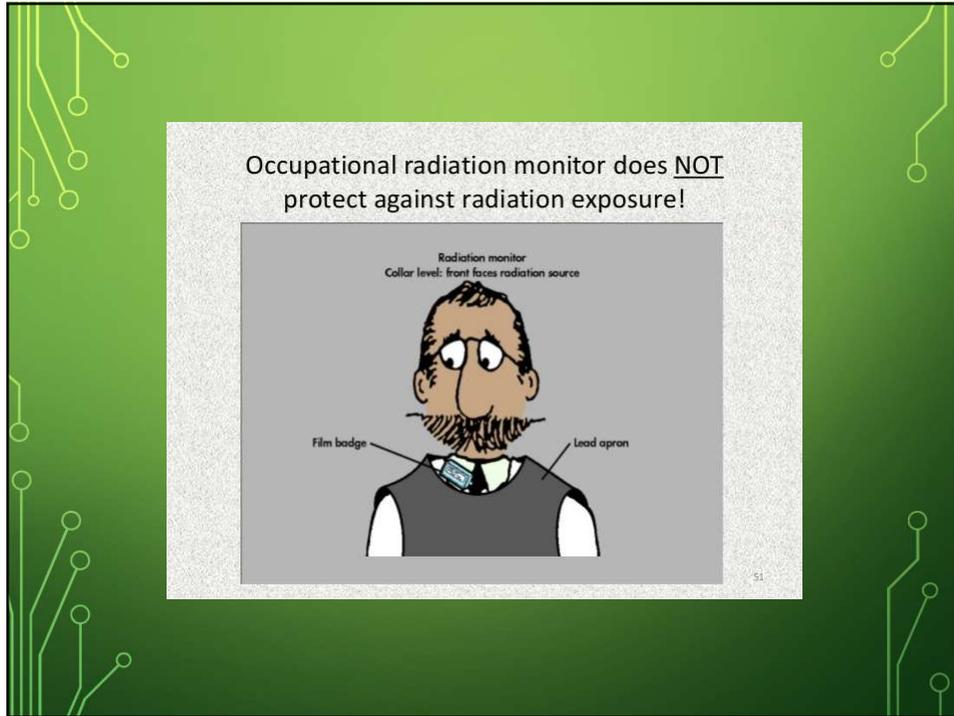
Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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

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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

LANDAUER[®]
LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 Account: 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	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									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: 2022-03-01 to 2023-02-29								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9075484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9075485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9075486L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00714	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9075487L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00720	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9075488L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00725	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9075489L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00737	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9075490L
	ASSIGNED NOTE							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 (mSv)

Whole Body, Most Sensitive Organs, Adults	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Pregnant female)	500
General Public	100

Based on the 10 NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may address or otherwise limit.

Dosimeter Description: A dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during work. At the customer's facility, when the dosimeter is in a radiation-free area during the work period.

Minimal Dose Equivalent Reported: Dose measurements below the minimal measurable quantity for the current monitoring period are recorded as "0". The minimal reporting level may vary by the dosimeter type and radiation quality. "0" can also mean "upset" for the internal dose equivalent report when exposures less than 10 mrem report as "0". Includes total dose equivalent, and/or exposures of more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (Dose Equivalent)	M (Dose Only)	SL
Lead	1	-	10
Ring	5	-	50
Whole Body	-	10	10
Li Ring	-	30	-
Neutron Monitor/Fast	10	-	-
Neutron Thermal/Fast	10	-	-
Skin Ring	-	10	10

Special Considerations: Dosimeter calibration can be applied by radiation workers who wear lead aprons.

ED1: 1 - eye dosimeter, one worn on the nasal bridge under lead apron and one worn at the collar level outside lead apron. 1.0 (Max ED1) = 0.04 (Collar DDE) = Assigned Dose Equivalent.

ED2: 2 - eye dosimeter, one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Dose Equivalent.

ED3: 3 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED4: 4 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED5: 5 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED6: 6 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED7: 7 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED8: 8 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED9: 9 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED10: 10 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED11: 11 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED12: 12 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

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ED17: 17 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

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ED91: 91 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED92: 92 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED93: 93 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED94: 94 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED95: 95 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED96: 96 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED97: 97 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED98: 98 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED99: 99 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED100: 100 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

Use	Description	Use	Description
AREA	Area Monitor	CELEST	Other Extremity
CHGRT	Cloud	DWGRDY	Other Whole Body
CTRL	Control	FINSLC	Right Arm
DCLAN	Collar	AFGRD	Right Hand/Thng
ED1	Eye	HEAMR	Right Upper Arm
FETAL	Fetal	FLLED	Right Upper Leg
LEADL	Left Hand	RMWGT	Right Hand
LFHND	Left Hand Ring	RFCHN	Special Feature
LFUPR	Left Upper Arm	LFBACK	Upper Back
LLLEG	Left Lower Leg	WABT	Waist
LRBACK	Lower Back	WBODY	Whole Body
LWRST	Left Wrist		

Code	Radiation Quality Description (Type and Energy)
B	beta
BE	beta high energy, e.g. Thorium, Protactinium
BL	beta low energy, e.g. Thallium, Tritium
BD	bremsstrahlung
BT	Thallium beta
BU	Uranium beta
BF	beta, neutron mixture
BB	neutron fast
BN	neutron thermal
P	proton (or gamma ray)
PB	proton, beta mixture
PBN	proton, beta, neutron mixture
PH	proton high energy greater than 200 keV
PL	proton low energy less than 40 keV
PM	proton medium energy 40 keV to 200 keV
PG	proton, neutron mixture

First 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	X	Gamma	Beta	Fast Neutron
FD-light Model 2	LD200	Yes	Yes	Yes	Yes	
FD-light Model 1.1	LD100	Yes	Yes	Yes	Yes	Yes
LD-light Model 2.1	LD210	Yes	Yes	Yes	Yes	Yes
Lead	LE	Yes	Yes	Yes	Yes	
Lead	LE	Yes	Yes	Yes	Yes	Yes
Lead	LE	Yes	Yes	Yes	Yes	Yes
Lead	LE	Yes	Yes	Yes	Yes	Yes
Lead	LE	Yes	Yes	Yes	Yes	Yes
Neutron	N					Yes
Neutron	N					Yes
Ring, Single TLD	LR10	Yes	Yes	Yes	Yes	

Dose, Eye and Shallow Dose Equivalents: Deep dose equivalent (DDE) applies to external whole body exposure at a dose depth of 1 cm (3000 mg/cm²). Eye dose equivalent (EDE) applies to external exposure of the lens at a dose depth of 0.3 cm (300 mg/cm²). Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a dose depth of 0.007 cm (7 mg/cm²) averaged over an area 1 cm².

Dose, Eye and Shallow Dose Equivalents: Report for the time frame indicated by the Monitoring Period. These doses represent the dose received only to the measurement specified. Individual calculation component results and combined totals report in separate form.

Quarterly accumulated results: reflect total dose received within a quarterly 3-month time frame and the customer defined start day. Quarterly accumulated values are determined for quarterly service or display. Total applicable 75 Year or date equivalent beta dose received from the beginning of the current year to report date. Lifetime accumulated beta dose received from inception date of dosimeter service to report date, and total include earlier dose history if available to customer. Reported quarterly annual and lifetime dose accumulations represent the beta dosing from all measurement/accumulation to be reported at the customer level.

Receipt Date: The date LANDAUER began keeping dosimeter records for a given customer for a badge purchased on the current customer.

Serial Number: Dosimeter part number.

Second Line Explanation
Participant Identification number consisting of ID number and birth date. This information can be represented on "Thumbnail and Single Report" for privacy and/or pending needs.

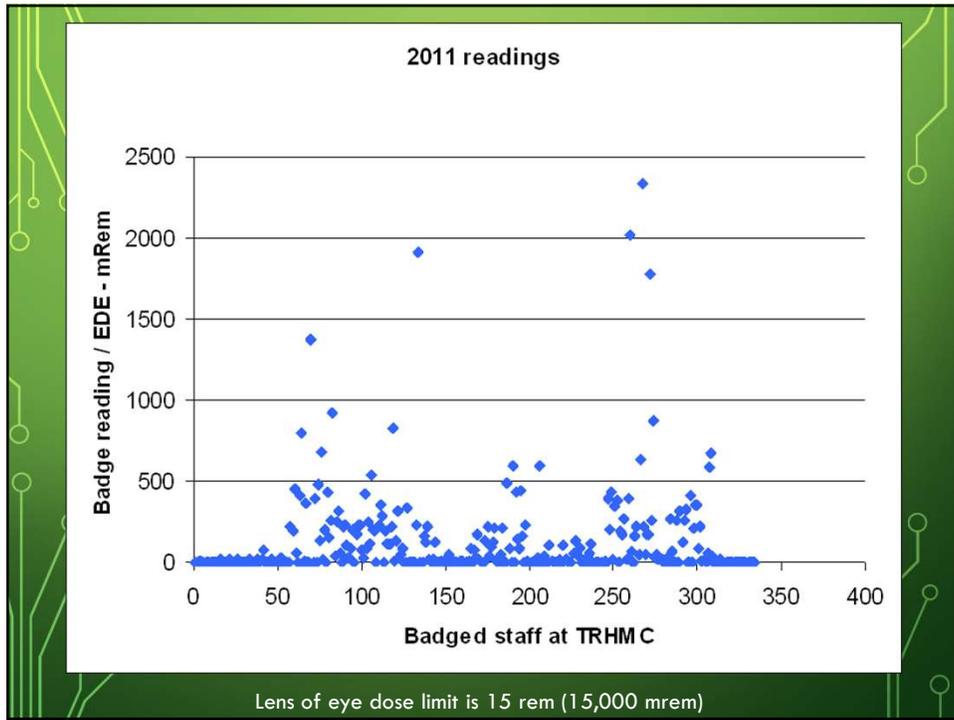
Note: Total measured exposure may differ slightly as compared to the badge with the nearest activity of 1 mSv or less below all dosimeter exposure information.

SL, Patient
SL1, SL2, SL3, SL4, SL5, SL6, SL7, SL8, SL9, SL10

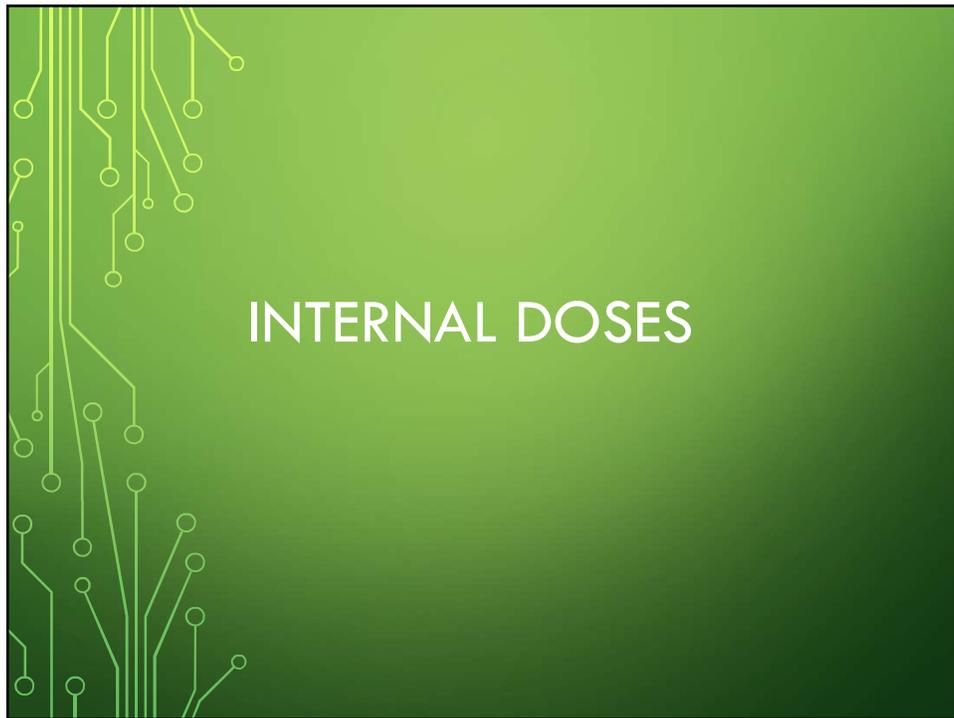
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How to Read Your Dosimetry Report from LANDAUER - YouTube

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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.....

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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

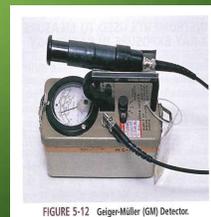


FIGURE 5-12 Geiger-Müller (GM) Detector.

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%



46

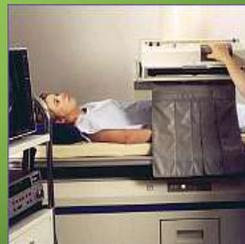
EQUIPMENT SURVEYS

- 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

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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



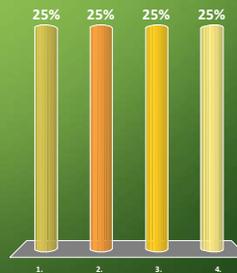
48

REVIEW QUESTIONS

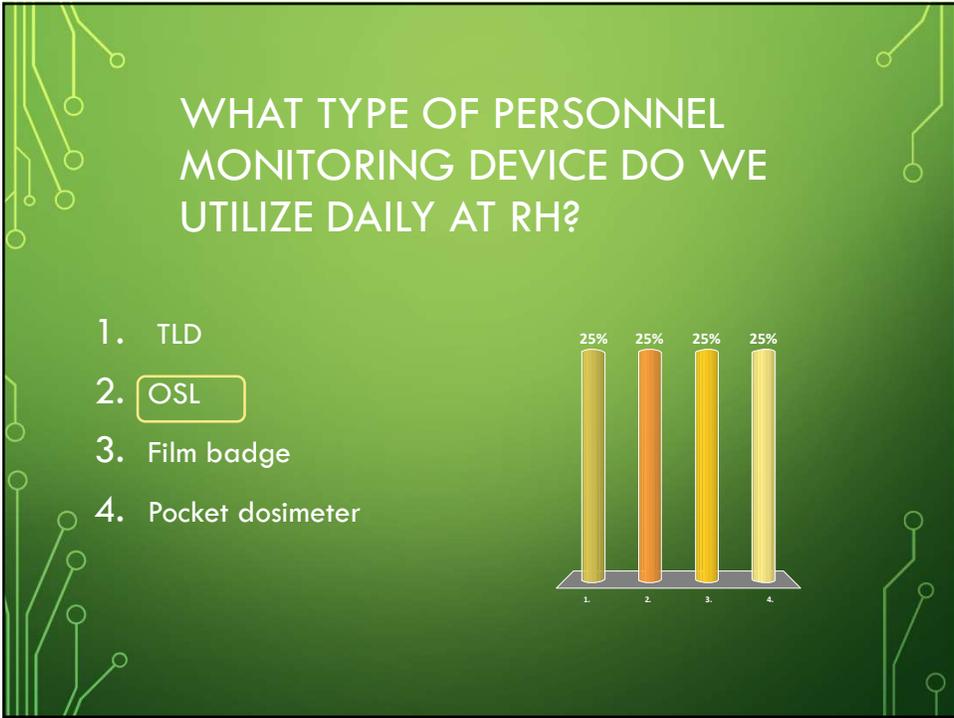
49

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

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



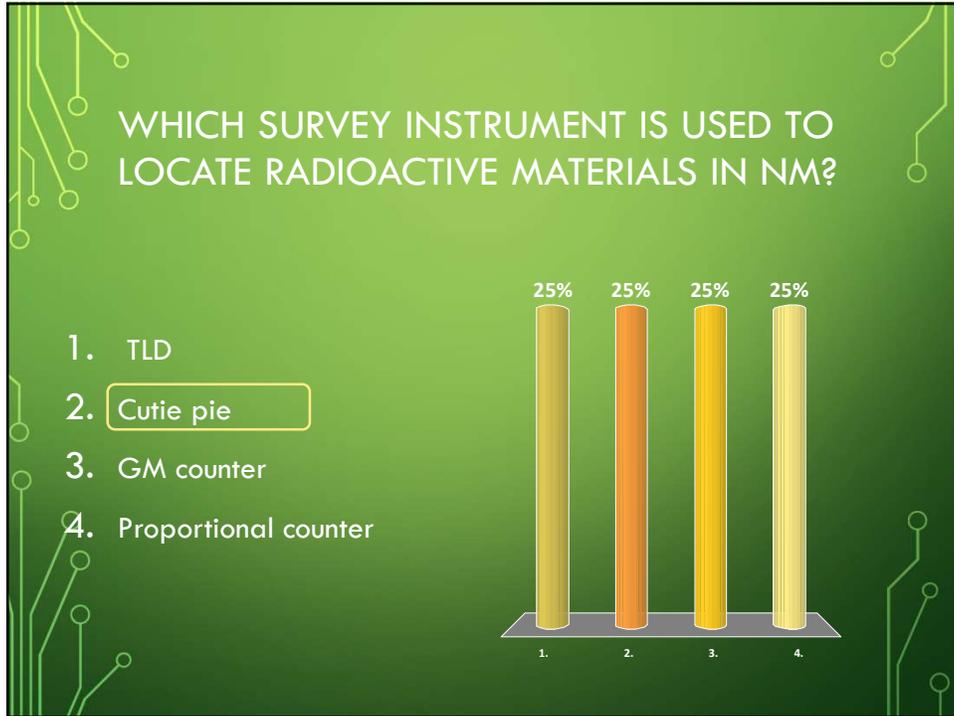
50



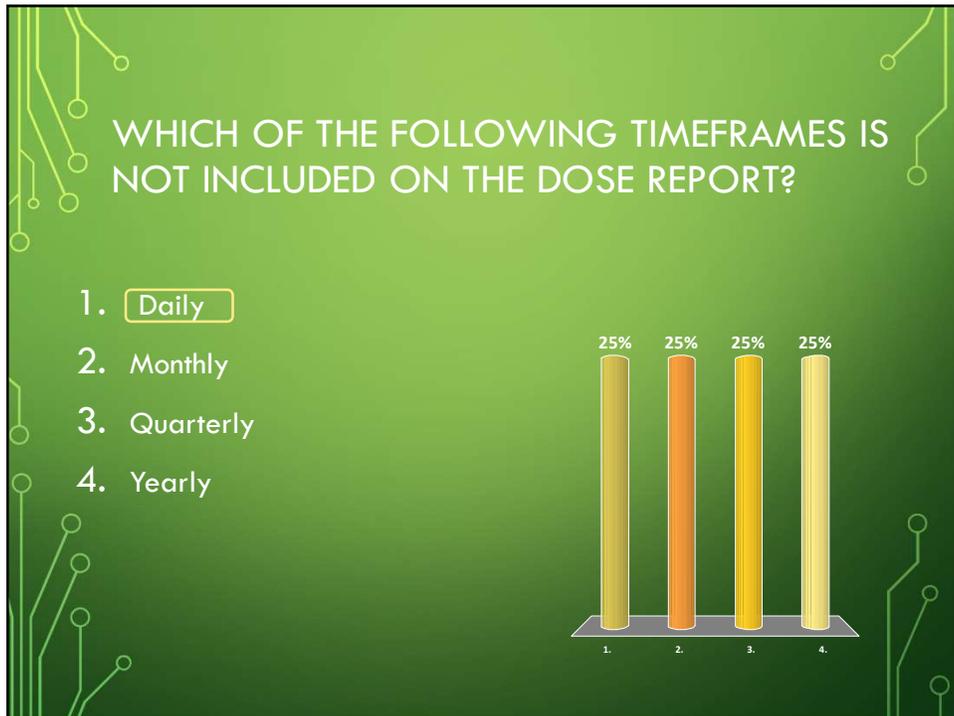
51



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WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

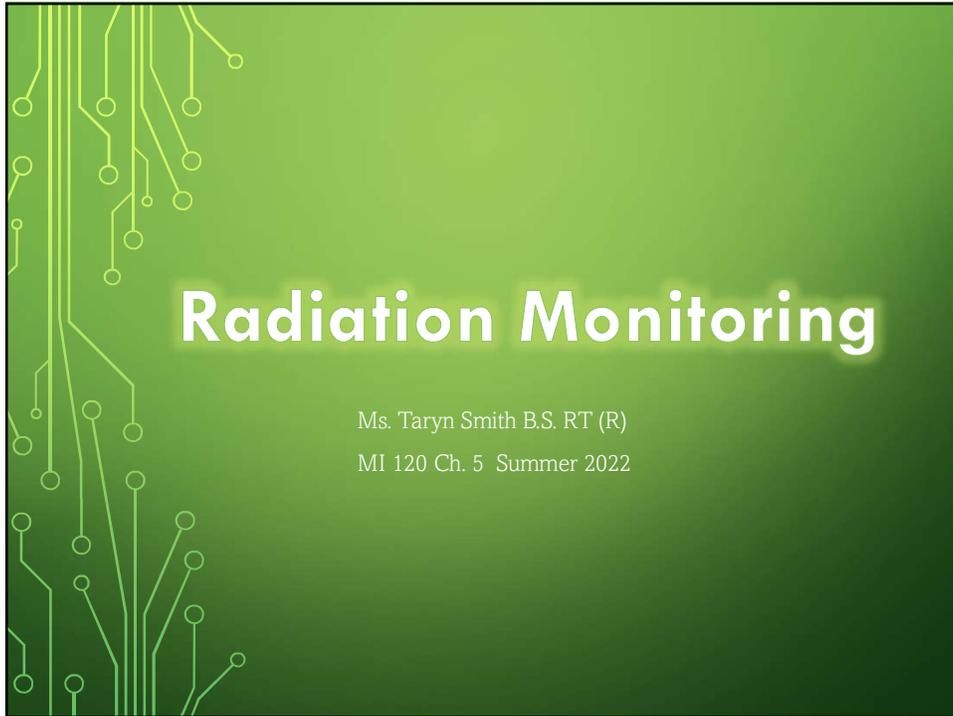
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Sensing Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

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Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

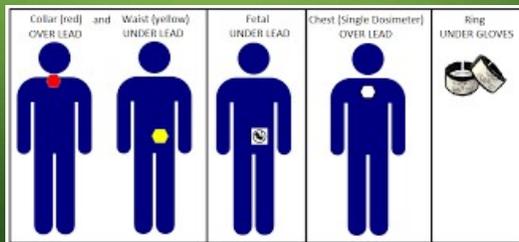


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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



8

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 0.1 mGy
 - 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 to be sent out to be read



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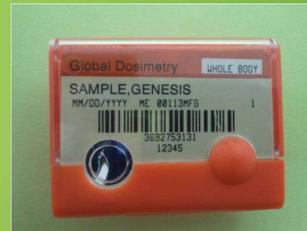
TLD- THERMOLUMINESCENT DOSIMETER

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



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TLD ADVANTAGES



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

14

TLD DISADVANTAGES

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



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



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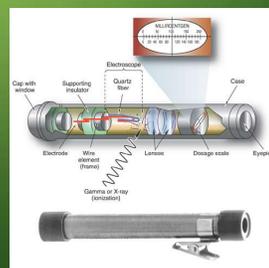
OSL DISADVANTAGES

- 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

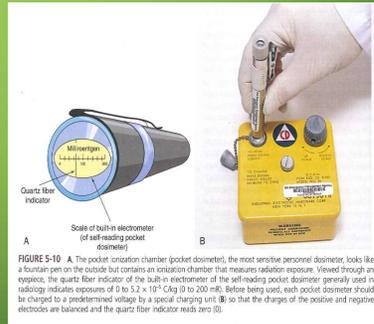
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



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POCKET IONIZATION CHAMBER ADVANTAGES

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



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

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DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

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	Badge Type #1 Instadose®2	Badge Type #2 Instadose®3	Badge Type #3 Instadose®4	Badge Type #4 APex™	Badge Type #5 (LUMC) & R-223/23P or 23-35	Badge Type #6 Genesis Ultra TLD™	Badge Type #7 Measuring™	Badge Type #8 Ultra™ & Flex™
Personal Dosimeters								
Overview	All the advantages reported of traditional, non-etch measurements for film badge systems.	Instantaneous wireless reporting enables immediate action/feedback for film badge systems.	The only etched CDU compatible dosimeter available for use with real-time reporting.	After dosimeter can be read multiple times, enabling an evaluation into several exposures.	Genesis Ultra TLD dosimeters, Genesis Ultra TLD-Blue are read using a standard TLD reader.	Easy and frequent dosimeter use ideal for low or high energy beta, X-ray or gamma radiation monitoring of hands and fingers.		
Features	<ul style="list-style-type: none"> • Durable and long exposure time of dose reads on mobile smart devices, Instadose 2 (iOS) or Instadose™ 3 (Android™). • 90% reduced background noise process. • Removable battery reporting. • Identical, on demand dose reads. • Recharge, replace and upgrade dose reads. 	<ul style="list-style-type: none"> • Bluetooth wireless transmission of dose reads on mobile smart devices, Instadose 2 (iOS) or Instadose™ 3 (Android™). • 90% reduced background noise process. • Removable battery reporting. • Identical, on demand dose reads. • Recharge, replace and upgrade dose reads. 	<ul style="list-style-type: none"> • Etched dose reads. • Durable and long exposure time of dose reads on mobile smart devices, Instadose 2 (iOS) or Instadose™ 3 (Android™). • Removable battery reporting. • Improved compliance. 	<ul style="list-style-type: none"> • Removable dosimeter for use on-site and in the field. • White body, easy monitoring. • Rechargeable. • Flexible display panel: accurate reading even when exposed to various temperatures or moisture. 	<ul style="list-style-type: none"> • New generation of TLDs in form of discs and in the field. • Durable and long exposure time of dose reads on mobile smart devices, Instadose 2 (iOS) or Instadose™ 3 (Android™). • Removable battery reporting. • Identical, on demand dose reads. • Recharge, replace and upgrade dose reads. 	<ul style="list-style-type: none"> • Individually calibrated. • Available in 4 sizes. • Can be immersed in water and used for monitoring. • Standardized (ISO) up to Class A (ANSI/N4244.1) or Class B (ANSI/N4244.2). • Same as the badge used by US, etc. 	<ul style="list-style-type: none"> • Strong hand/glove construction. • Available in 3 sizes. • Flex Ring. • Full plastic construction with index (Class A only). • Dose and Time Ring (used by Instadose™). 	
Applications	Requires personnel exposed to ionizing radiation. Can also be used for area monitoring.	Requires personnel exposed to ionizing radiation. Can also be used for area monitoring.	Requires personnel exposed to ionizing radiation. Can also be used for area monitoring.	Requires personnel exposed to ionizing radiation. Can also be used for area monitoring.	Requires personnel exposed to ionizing radiation. Can also be used for area monitoring.	Individual handling, subdosimetry, performance enhancement, radiographic protection, or other areas of radiation exposure in both hands and fingers.		
Description	Real Time Dosimeter (RTD) with Real Time Reporting (RTM) and Real Time Reporting (RTM) Technology (MIRION®) Real Time Reporting (RTM) Technology.	Real Time Dosimeter (RTD) with Real Time Reporting (RTM) and Real Time Reporting (RTM) Technology (MIRION®) Real Time Reporting (RTM) Technology.	Real Time Dosimeter (RTD) with Real Time Reporting (RTM) and Real Time Reporting (RTM) Technology (MIRION®) Real Time Reporting (RTM) Technology.	Real Time Dosimeter (RTD) with Real Time Reporting (RTM) and Real Time Reporting (RTM) Technology (MIRION®) Real Time Reporting (RTM) Technology.	Real Time Dosimeter (RTD) with Real Time Reporting (RTM) and Real Time Reporting (RTM) Technology (MIRION®) Real Time Reporting (RTM) Technology.	Single Chip TLD, Ca, F Phosphor Crystals (LUMC).	Single Chip TLD, Ca, F Phosphor Crystals (LUMC).	Single Chip TLD, Ca, F Phosphor Crystals (LUMC).
Min. Reportable Dose (MRD) & Useful Dose Range	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv	0.05 mSv, 0.01 mSv* 0.01 mSv - 15 Sv
Energy Response	Photo: 1 mSv - 6 mSv Beta: 0.1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv	Photo: 1 mSv - 6 mSv
Accreditations	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)	US: NIST (see 19105.0) NIST (see 19105.0) NIST (see 19105.0)
Holder Type Prog. size and requirements for exposure.	AWARD WINNING PATENT Most Innovative On-Demand Dosimetry System			BP (Blue Body)	DA, DL, DM			

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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

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Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

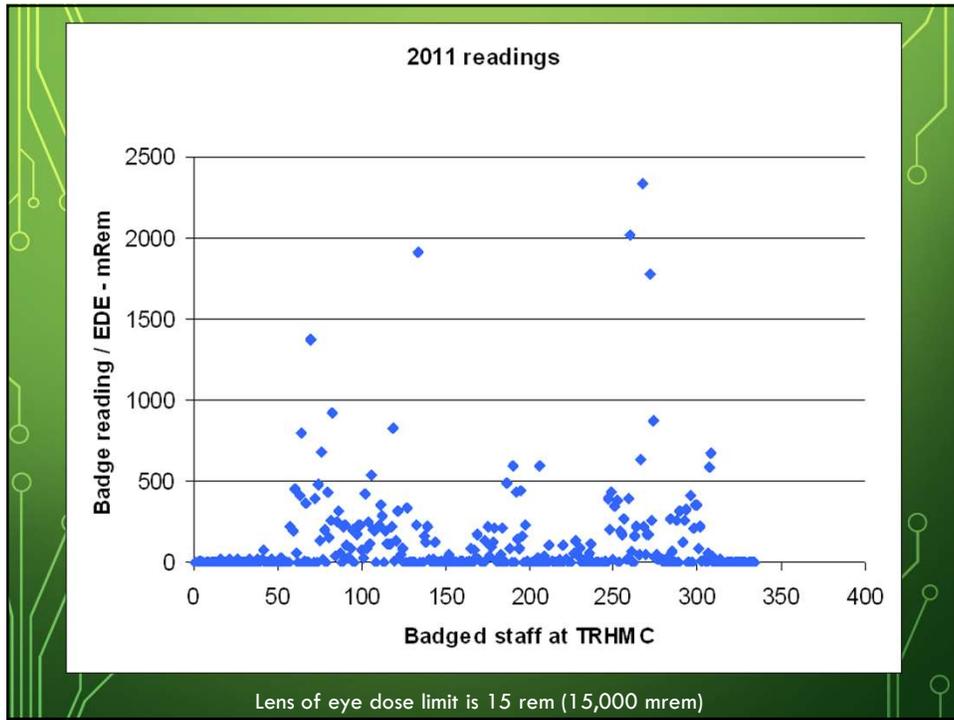
Account : 719 Account: 1456718 Series: SHS

*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.

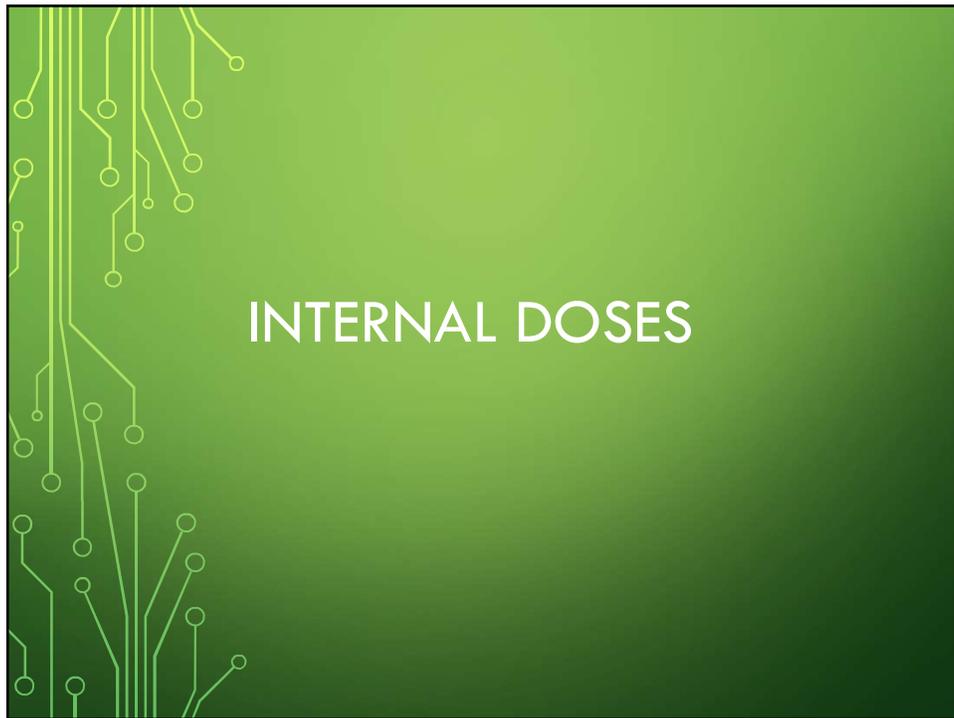
Participant Number	Name	ID Number	Birth Date	Dosimeter	Use	Read Time	Read Quality	Dose Equivalent (mrem) for Periods Shown Below									Inception Date	Serial Number						
								Period Shown Below			Quarter to Date			Year to Date					Lifetime to Date					
								DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE			DDE	LDE	SDE			
For Monitoring Period: 2022-03-01 to 2023-02-29								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9075484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9075485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9075486L
00714	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9075487L
00720	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9075488L
00725	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9075489L
00737	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9075490L

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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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

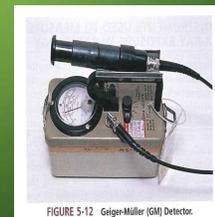


FIGURE 5-12 Geiger-Müller (GM) Detector.

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

44

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

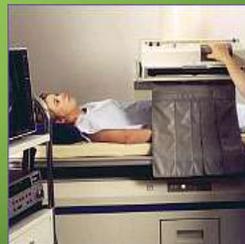
EQUIPMENT SURVEYS

- 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



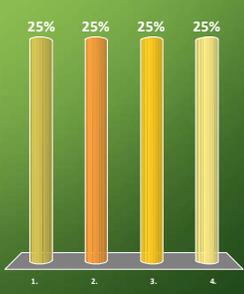
48

REVIEW QUESTIONS

49

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

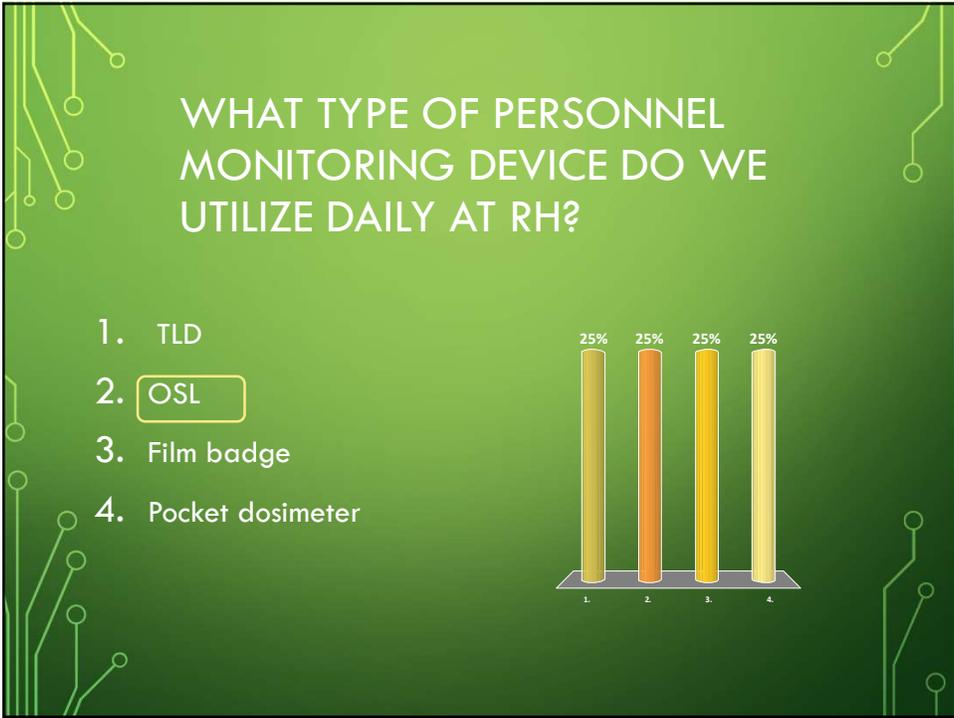
- 1. Deep dose
- 2. Shallow dose
- 3. Eye dose
- 4. Lens dose



A bar chart with four bars, each labeled '25%' above it. The bars are numbered 1, 2, 3, and 4 from left to right. The bars are colored in a gradient from light yellow to light orange.

Option	Percentage
1. Deep dose	25%
2. Shallow dose	25%
3. Eye dose	25%
4. Lens dose	25%

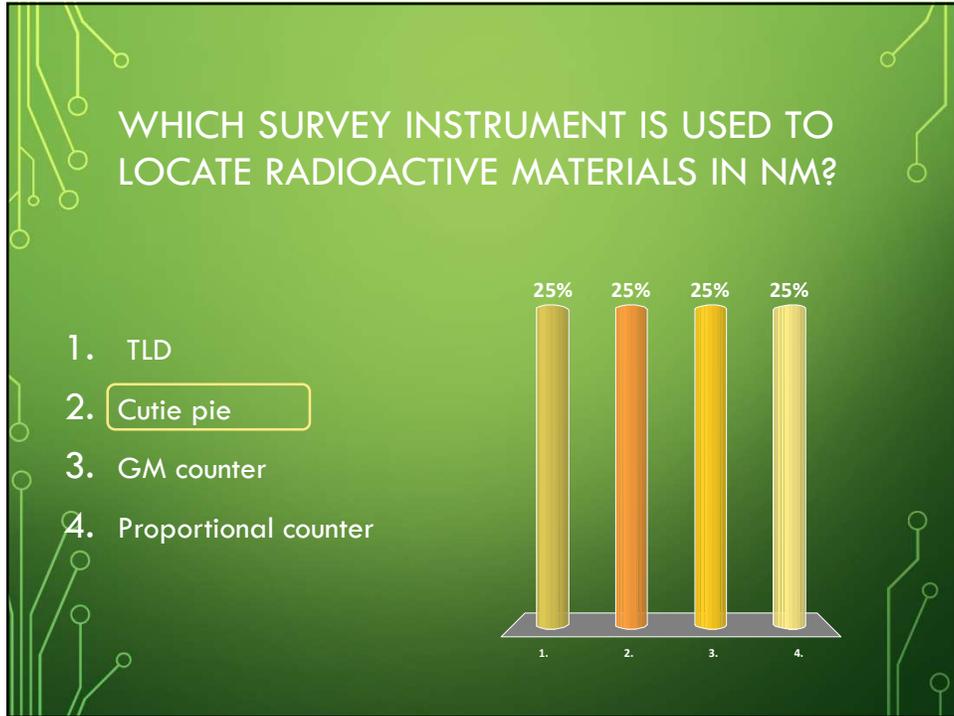
50



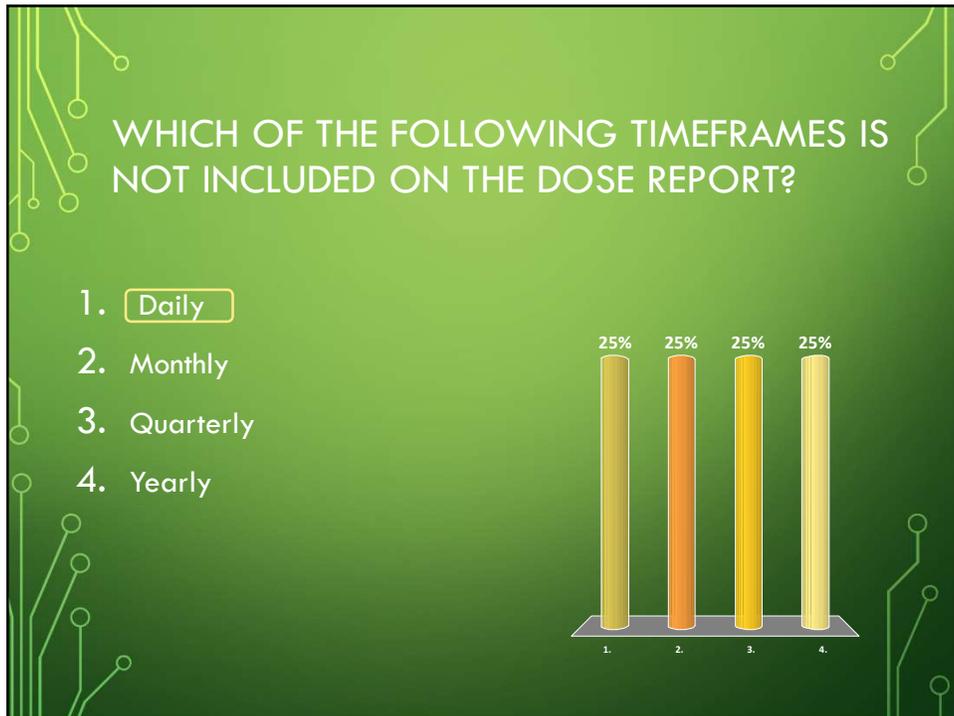
51



52



53



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

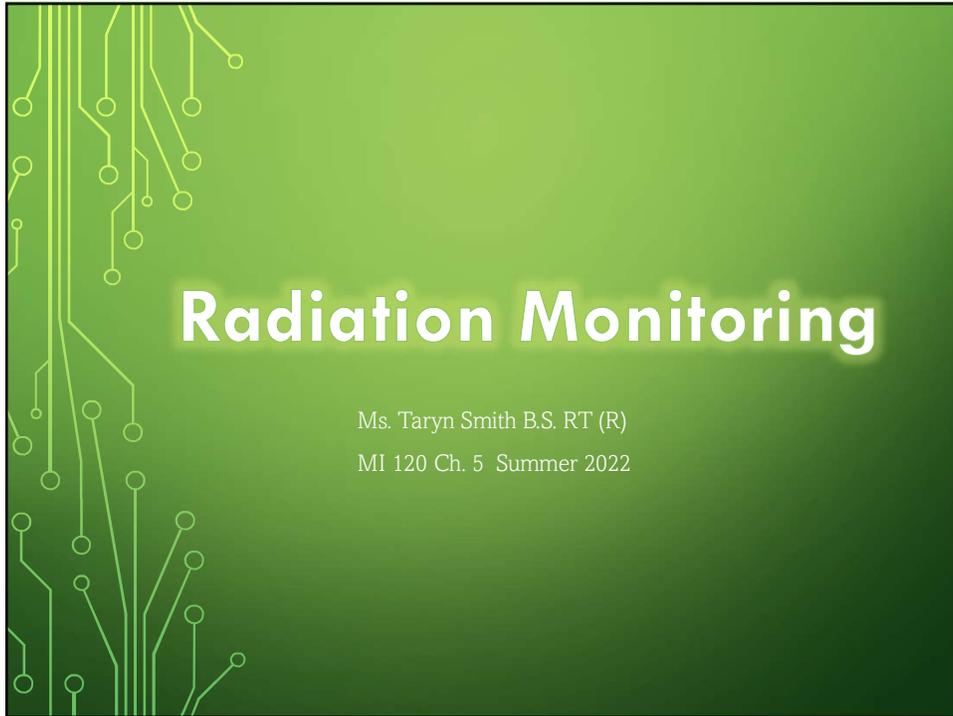
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Sensing Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

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57



Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

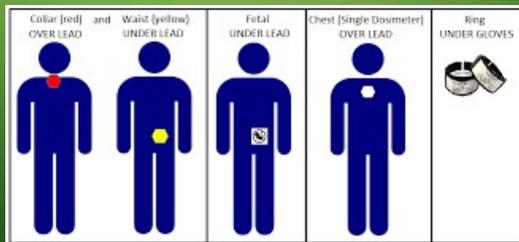


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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 0.1 mGy
 - 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 to be sent out to be read



12

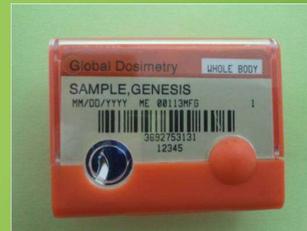
TLD- THERMOLUMINESCENT DOSIMETER

- 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

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TLD DISADVANTAGES

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



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



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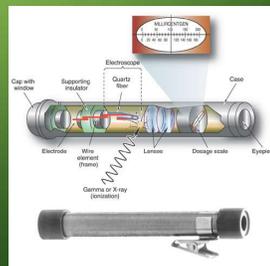
OSL DISADVANTAGES

- 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

19

POCKET IONIZATION CHAMBER

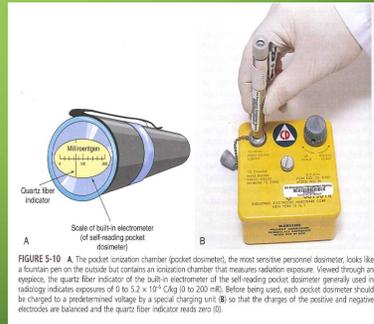
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



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POCKET IONIZATION CHAMBER ADVANTAGES

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



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

21

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



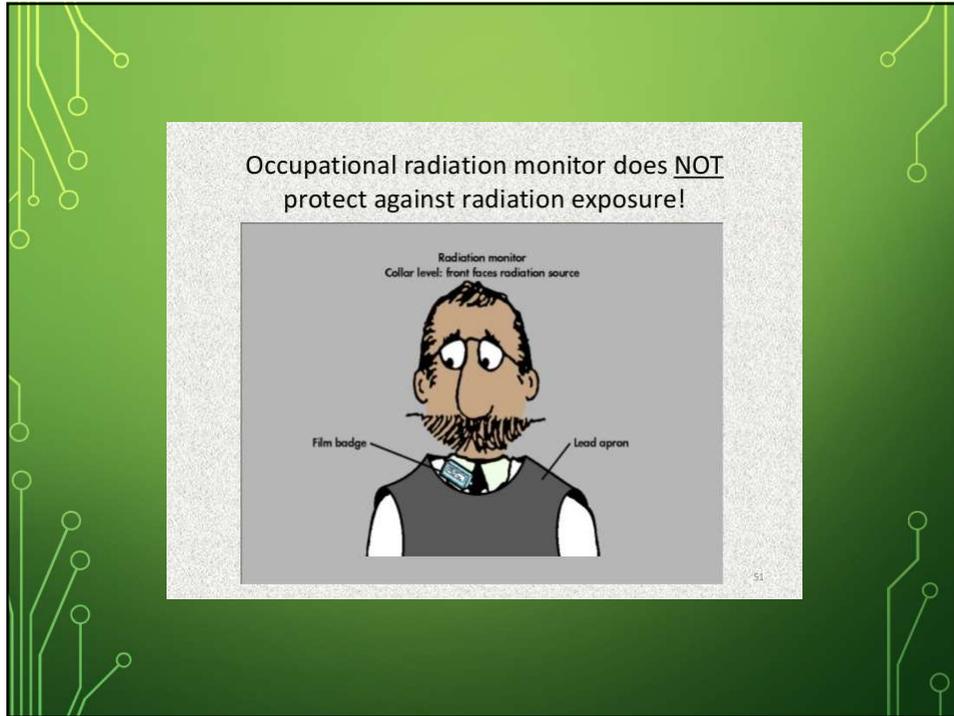
Radiation Protection in Medical Radiography,
9th Ed. Statkiewicz Sherer

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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

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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

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Analytical Work Order / QC Release	2287700129 / LCA
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NVLAP LAB CODE 105518-0

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Glenwood, Illinois 60425-1586
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Customer Service: (800) 323-8850
Technical: (800) 438-3241

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Participant Number	Name	ID Number	Birth Date	Dosimeter	Use	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									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: 2022-03-01 to 2022-03-28								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
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Radiation Dosimetry Report

Annual Radiation Exposure Limits (mSv)

Whole Body, Most Sensitive Organs, Adults	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Pregnant female)	500
General Public	100

Based on the 10 NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may address or otherwise limit.

Dosimeter Description: A dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during work. At the customer's facility, when the dosimeter is in a radiation-free area during the work period.

Minimal Dose Equivalent Reported: Dose measurements below the minimal measurable quantity for the current monitoring period are reported as "0". The minimal reporting level may vary by the dosimeter type and radiation quality. "0" can also mean "up to the minimal dose equivalent reported unless exposure is less than 10 mrem report as "0". Includes total dose equivalent, unless exposure is more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (Dose Equivalent)	M (Dose Only)	SL
Lead	1	-	10
Ring	5	-	50
Whole Body	-	10	10
Li Ring	-	30	-
Neutron Monitor/Facet	10	-	-
Neutron Monitor/Thermal/Facet	10	-	-
Skin Ring	-	10	10

Special Considerations: Dosimeter dose calibration can be applied by radiation workers who wear lead aprons.

ED1: 1 - eye dosimeter, one worn on the nasal bridge under lead apron and one worn at the collar level outside lead apron. 1.0 (Max ED1) = 0.04 (Collar DDE) = Assigned Dose Equivalent.

ED2: 2 - eye dosimeter, one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Dose Equivalent.

ED3: 3 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED4: 4 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED5: 5 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED6: 6 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED7: 7 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED8: 8 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED9: 9 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED10: 10 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED11: 11 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED12: 12 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED13: 13 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED14: 14 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED15: 15 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED16: 16 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED17: 17 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED18: 18 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED19: 19 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED20: 20 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED21: 21 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED22: 22 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED23: 23 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED24: 24 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED25: 25 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED26: 26 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED27: 27 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED28: 28 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED29: 29 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED30: 30 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED31: 31 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED32: 32 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED33: 33 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED34: 34 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED35: 35 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED36: 36 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED37: 37 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED38: 38 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED39: 39 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED40: 40 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED41: 41 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED42: 42 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED43: 43 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED44: 44 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED45: 45 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED46: 46 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED47: 47 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED48: 48 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED49: 49 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED50: 50 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED51: 51 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED52: 52 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED53: 53 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED54: 54 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED55: 55 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED56: 56 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED57: 57 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED58: 58 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED59: 59 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED60: 60 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED61: 61 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED62: 62 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED63: 63 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED64: 64 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED65: 65 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED66: 66 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED67: 67 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED68: 68 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED69: 69 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED70: 70 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED71: 71 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED72: 72 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED73: 73 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED74: 74 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED75: 75 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED76: 76 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED77: 77 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED78: 78 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED79: 79 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED80: 80 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED81: 81 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED82: 82 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED83: 83 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED84: 84 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED85: 85 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED86: 86 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED87: 87 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED88: 88 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED89: 89 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED90: 90 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED91: 91 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED92: 92 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED93: 93 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED94: 94 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED95: 95 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED96: 96 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED97: 97 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED98: 98 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED99: 99 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED100: 100 - eye dosimeter, one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

Use	Description	Use	Description
AREA	Area Monitor	CELEST	Celex
CHGRT	Cloud	DWGRDY	Other Whole Body
CTRL	Control	FINSLC	Right Arm
DCLAN	Collar	AFGRD	Right Hand/Thng
ED1	Eye	HEAMR	Right Upper Arm
FETAL	Fetal	FLLED	Right Upper Leg
LEADL	Lead	AWRGT	Right Hand
LFRMR	Left Hand Arm	DFCPR	Special Purpose
LFRMR	Left Upper Arm	DFBAC	Upper Back
LLEAD	Left Upper Leg	WABT	Wrist
LWBAC	Lower Back	WBWDY	Whole Body
LWRST	Left Wrist		

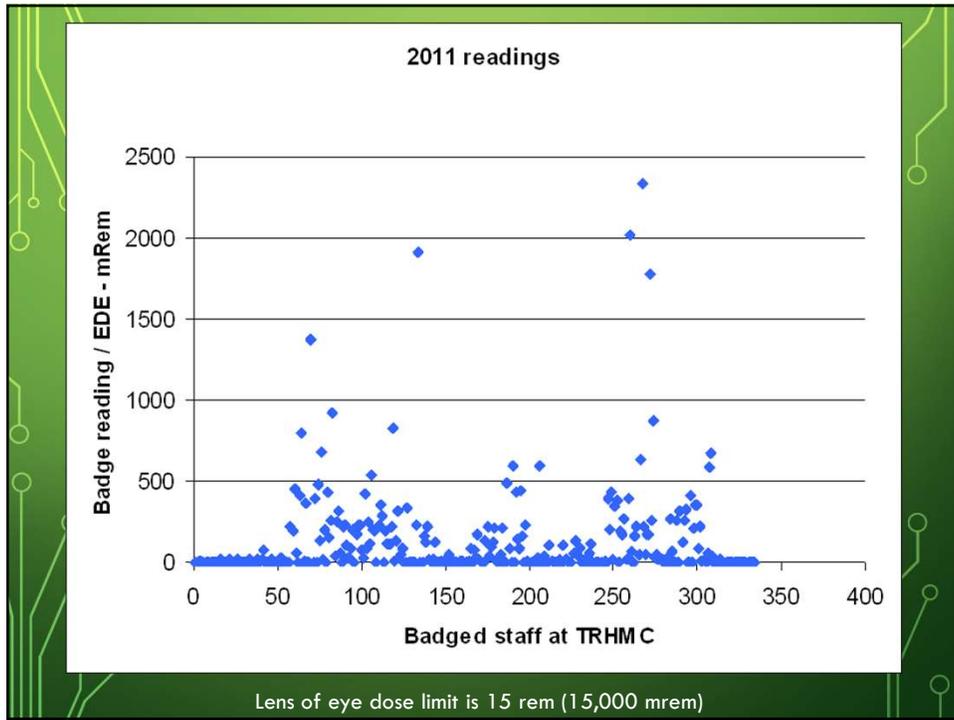
Code	Radiation Quality Description (Type and Energy)
B	beta
BE	beta high energy, e.g. Thorium, Protactinium
BL	beta low energy, e.g. Thallium, Tritium
BD	bremsstrahlung
BT	Thallium beta
BU	Uranium beta
BF	beta, neutron mixture
BB	neutron fast
BN	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photon high energy greater than 200 keV
PL	photon low energy less than 40 keV
PH	photon medium energy 40 keV to 200 keV
PN	photon, neutron mixture

First 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

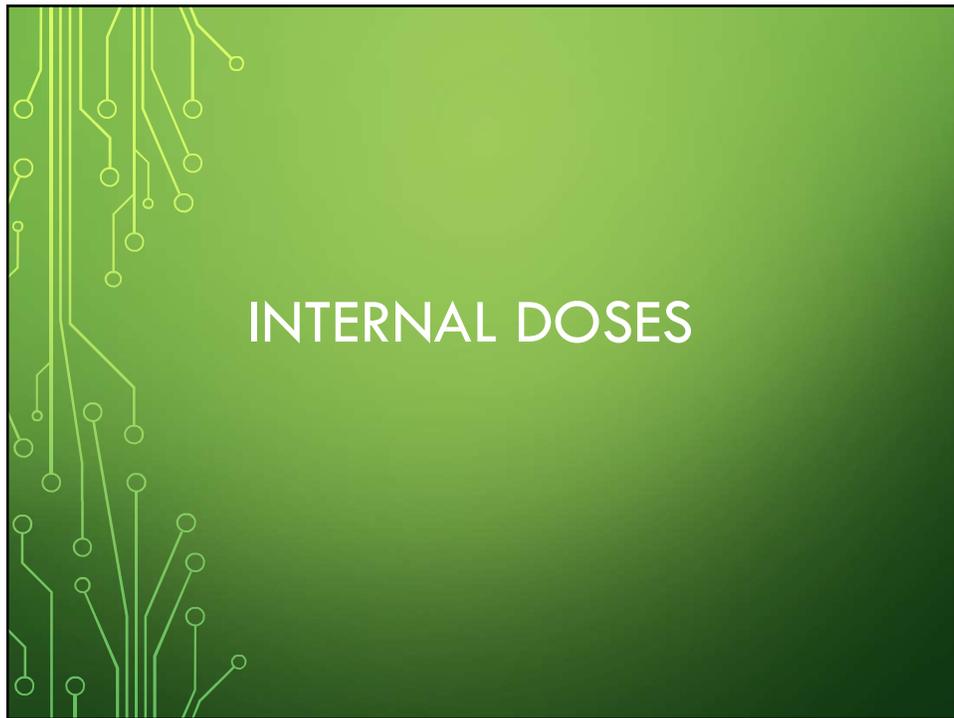
Dosimeter	Code	Type of Radiation Monitored				
		Photons	Neutrons	Fast	Thermal	Other
Full-Body	100000	Yes	Yes	Yes	Yes	Yes
Upper Back	100001	Yes	Yes	Yes	Yes	Yes
Upper Leg	100002	Yes	Yes	Yes	Yes	Yes
Upper Arm	100003	Yes	Yes	Yes	Yes	Yes
Hand	100004	Yes	Yes	Yes	Yes	Yes
Hand	100005	Yes	Yes	Yes	Yes	Yes
Hand	100006	Yes	Yes	Yes	Yes	Yes
Hand	100007	Yes	Yes	Yes	Yes	Yes
Hand	100008	Yes	Yes	Yes	Yes	Yes
Hand	100009	Yes	Yes	Yes	Yes	Yes
Hand	100010	Yes	Yes	Yes	Yes	Yes
Hand	100011	Yes	Yes	Yes	Yes	Yes
Hand	100012	Yes	Yes	Yes	Yes	Yes
Hand	100013	Yes	Yes	Yes	Yes	Yes
Hand	100014	Yes	Yes	Yes	Yes	Yes
Hand	100015	Yes	Yes	Yes	Yes	Yes
Hand	100016	Yes	Yes	Yes	Yes	Yes
Hand	100017	Yes	Yes	Yes	Yes	Yes
Hand	100018	Yes	Yes	Yes	Yes	Yes
Hand	100019	Yes	Yes	Yes	Yes	Yes
Hand	100020	Yes	Yes	Yes	Yes	Yes
Hand	100021	Yes	Yes	Yes	Yes	Yes
Hand	100022	Yes	Yes	Yes	Yes	Yes
Hand	100023	Yes	Yes	Yes	Yes	Yes
Hand	100024	Yes	Yes	Yes	Yes	Yes
Hand	100025	Yes	Yes	Yes	Yes	Yes
Hand	100026	Yes	Yes	Yes	Yes	Yes
Hand	100027	Yes	Yes	Yes	Yes	Yes
Hand	100028	Yes	Yes	Yes	Yes	Yes
Hand	100029	Yes	Yes	Yes	Yes	Yes
Hand	100030	Yes	Yes	Yes	Yes	Yes
Hand	100031	Yes	Yes	Yes	Yes	Yes
Hand	100032	Yes	Yes	Yes	Yes	Yes
Hand	100033	Yes	Yes	Yes	Yes	Yes
Hand	100034	Yes	Yes	Yes	Yes	Yes
Hand	100035	Yes	Yes	Yes	Yes	Yes
Hand	100036	Yes	Yes	Yes	Yes	Yes
Hand	100037	Yes	Yes	Yes	Yes	Yes
Hand	100038	Yes	Yes	Yes	Yes	Yes
Hand	100039	Yes	Yes	Yes	Yes	Yes
Hand	100040	Yes	Yes	Yes	Yes	Yes
Hand	100041	Yes	Yes	Yes	Yes	Yes
Hand	100042	Yes	Yes	Yes	Yes	Yes
Hand	100043	Yes	Yes	Yes	Yes	Yes
Hand	100044	Yes	Yes	Yes	Yes	Yes
Hand	100045	Yes	Yes	Yes	Yes	Yes
Hand	100046	Yes	Yes	Yes	Yes	Yes
Hand	100047	Yes	Yes	Yes	Yes	Yes
Hand	100048	Yes	Yes	Yes	Yes	Yes
Hand	100049	Yes	Yes	Yes	Yes	Yes
Hand	100050	Yes	Yes	Yes	Yes	Yes
Hand	100051	Yes	Yes	Yes	Yes	Yes
Hand	100052	Yes	Yes	Yes	Yes	Yes
Hand	100053	Yes	Yes	Yes	Yes	Yes
Hand	100054	Yes	Yes	Yes	Yes	Yes
Hand	100055	Yes	Yes	Yes	Yes	Yes
Hand	100056	Yes	Yes	Yes	Yes	Yes
Hand	100057	Yes	Yes	Yes	Yes	Yes
Hand	100058	Yes	Yes	Yes	Yes	Yes
Hand	100059	Yes	Yes	Yes	Yes	Yes
Hand	100060	Yes	Yes	Yes	Yes	Yes
Hand	100061	Yes	Yes	Yes	Yes	Yes
Hand	100062	Yes	Yes	Yes	Yes	Yes
Hand	100063	Yes	Yes	Yes	Yes	Yes
Hand	100064	Yes	Yes	Yes	Yes	Yes
Hand	100065	Yes	Yes	Yes	Yes	Yes
Hand	100066	Yes	Yes	Yes	Yes	Yes
Hand	100067	Yes	Yes	Yes	Yes	Yes
Hand	100068	Yes	Yes	Yes	Yes	Yes
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Hand	100071	Yes	Yes	Yes	Yes	Yes
Hand	100072	Yes	Yes	Yes	Yes	Yes
Hand	100073	Yes	Yes	Yes	Yes	Yes
Hand	100074	Yes	Yes	Yes	Yes	Yes
Hand	100075	Yes	Yes	Yes	Yes	Yes
Hand	100076	Yes	Yes	Yes	Yes	Yes
Hand	100077	Yes	Yes	Yes	Yes	Yes
Hand	100078	Yes	Yes	Yes	Yes	Yes
Hand	100079	Yes	Yes	Yes	Yes	Yes
Hand	100080	Yes	Yes	Yes	Yes	Yes
Hand	100081	Yes	Yes	Yes	Yes	Yes
Hand	100082	Yes	Yes	Yes	Yes	Yes
Hand	100083	Yes	Yes	Yes	Yes	Yes
Hand	100084	Yes	Yes	Yes	Yes	Yes
Hand	100085	Yes	Yes	Yes	Yes	Yes
Hand	100086	Yes	Yes	Yes	Yes	Yes
Hand	100087	Yes	Yes	Yes	Yes	Yes
Hand	100088	Yes	Yes	Yes	Yes	Yes
Hand	100089	Yes	Yes	Yes	Yes	Yes
Hand	100090	Yes	Yes	Yes	Yes	Yes
Hand	100091	Yes	Yes	Yes	Yes	Yes
Hand	100092	Yes	Yes	Yes	Yes	Yes
Hand	100093	Yes	Yes	Yes	Yes	Yes
Hand	100094	Yes	Yes	Yes	Yes	Yes
Hand	100095	Yes	Yes	Yes	Yes	Yes
Hand	100096	Yes	Yes	Yes	Yes	Yes
Hand	100097	Yes	Yes	Yes	Yes	Yes
Hand	100098	Yes	Yes	Yes	Yes	Yes
Hand	100099	Yes	Yes	Yes	Yes	Yes
Hand	100100	Yes	Yes	Yes	Yes	Yes

Dose, Eye and Shallow Dose Equivalent: Deep dose equivalent (DDE) applies to external whole body exposure at a dose depth of 1 cm (3000 mg/cm²). Eye dose equivalent (EDE) applies to external exposure of the lens at a dose depth of 0.3 cm (300 mg/cm²). Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a dose depth of 0.007 cm (0.7 mg/cm²) averaged over an area 1 cm².

Dose, Eye and Shallow Dose Equivalent: Report for the time



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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



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

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

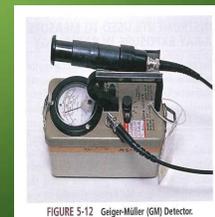


FIGURE 5-12 Geiger-Müller (GM) Detector.

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

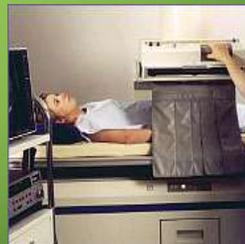
EQUIPMENT SURVEYS

- 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

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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



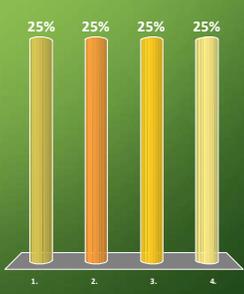
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REVIEW QUESTIONS

49

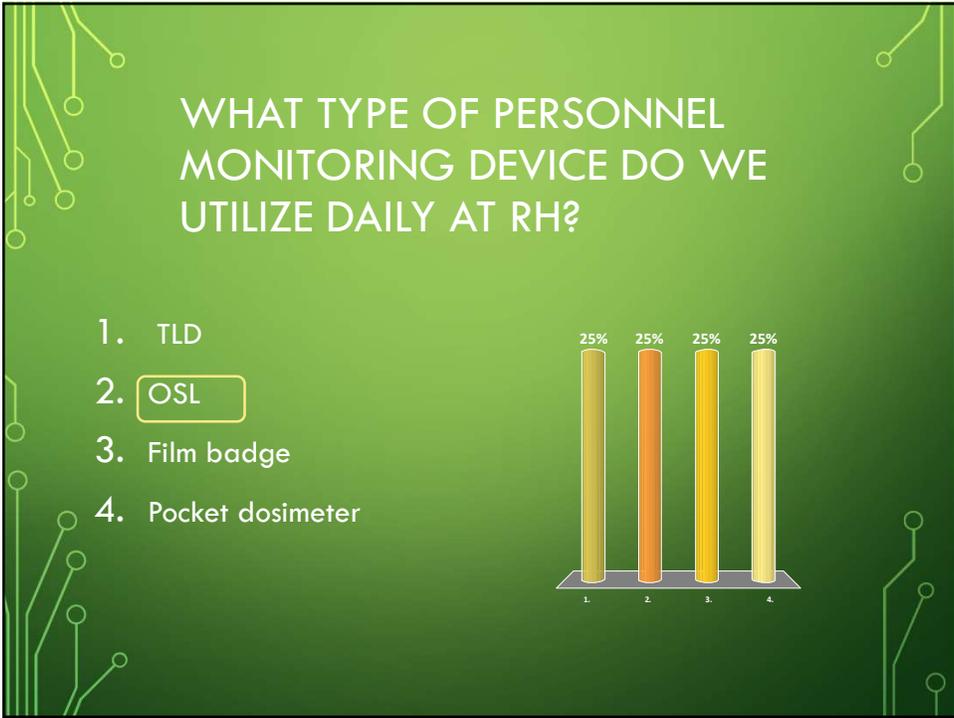
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

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



Option	Percentage
1. Deep dose	25%
2. Shallow dose	25%
3. Eye dose	25%
4. Lens dose	25%

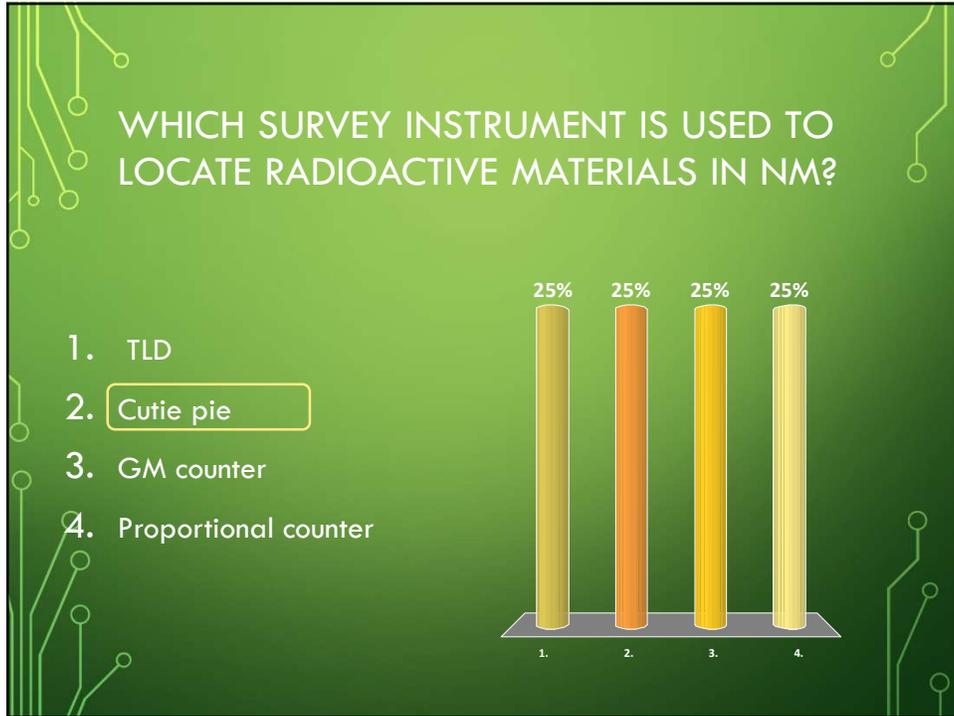
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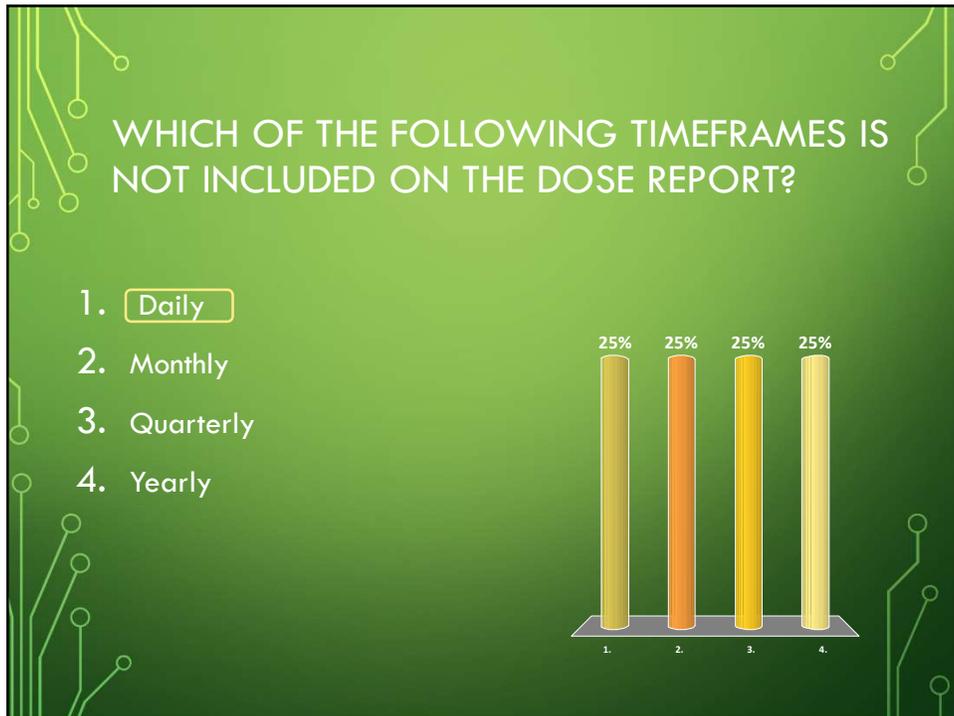
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53



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WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

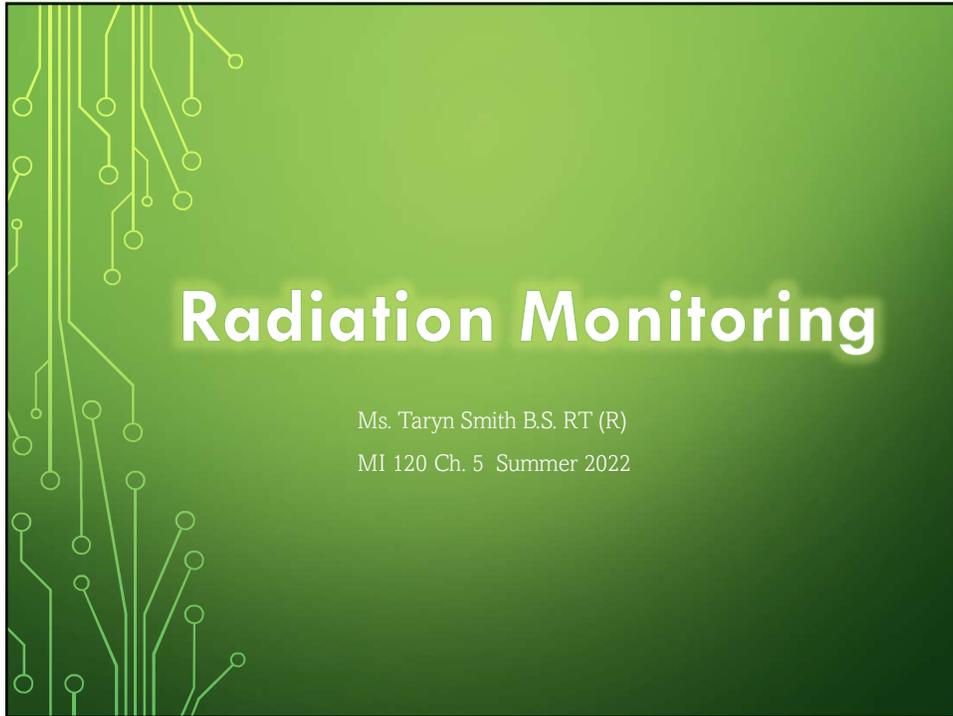
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

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Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

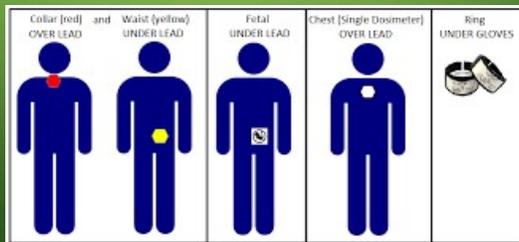


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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



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 0.1 mGy
 - 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 to be sent out to be read



12

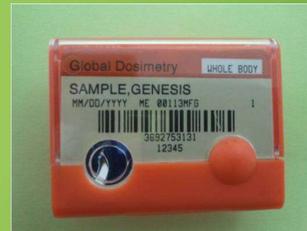
TLD- THERMOLUMINESCENT DOSIMETER

- 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 if not carefully recorded because once energy is released from crystals it cannot be reread
- Records only exposure to area in which it is worn



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

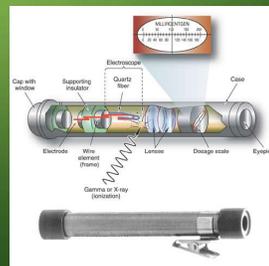
OSL DISADVANTAGES

- 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

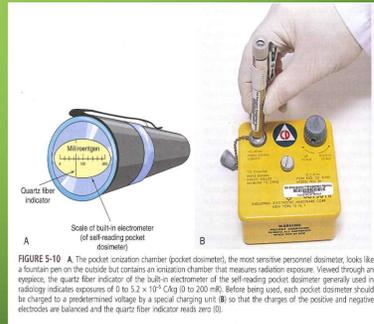


FIGURE 5-10 A. The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of 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

21

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



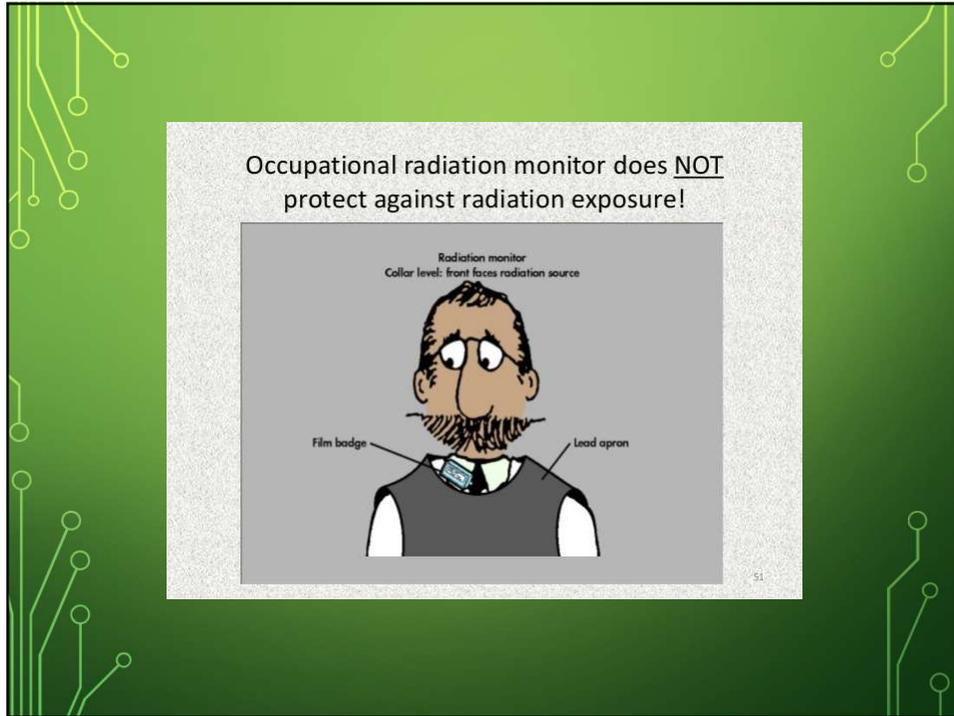
Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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



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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

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

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Glenwood, Illinois 60425-1586
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Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

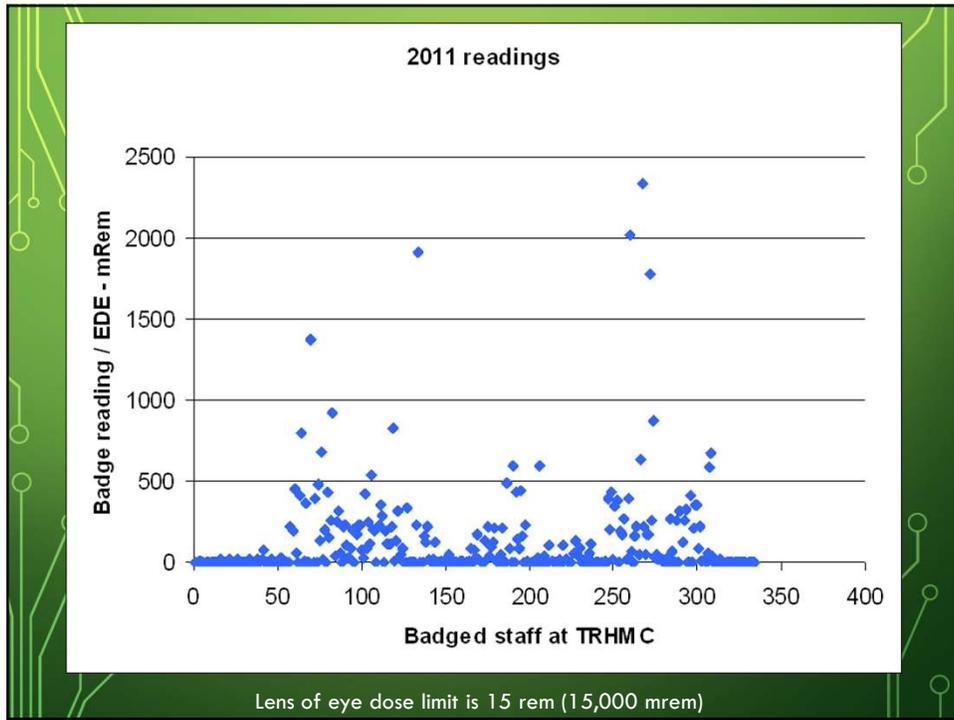
Account : 719 Account: 1456718 Series: SHS

*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.

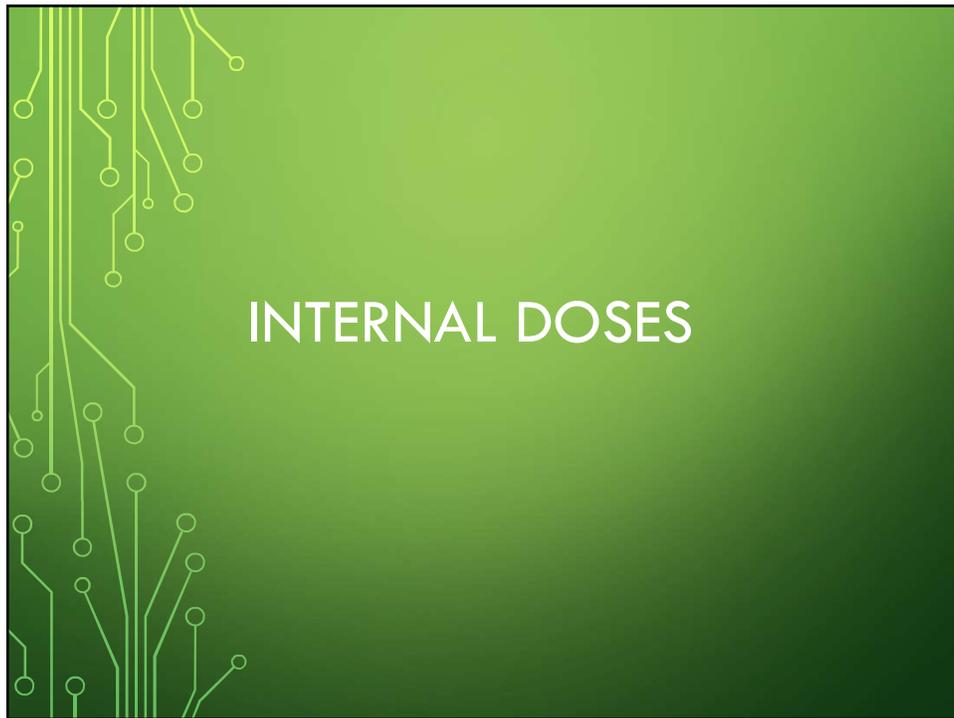
Participant Number	Name	ID Number	Birth Date	Dosimeter	Use	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									Inception Date	Serial Number						
								Period Shown Below			Quarter to Date			Year to Date					Lifetime to Date					
								DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE			DDE	LDE	SDE			
For Monitoring Period: 2022-03-01 to 2023-02-29								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9075484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9075485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9075486L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00714	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9075487L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00720	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9075488L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00725	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9075489L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00737	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9075490L
	ASSIGNED NOTE							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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33



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

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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



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

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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

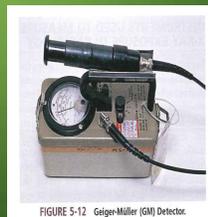


FIGURE 5-12 Geiger-Müller (GM) Detector.

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

44

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

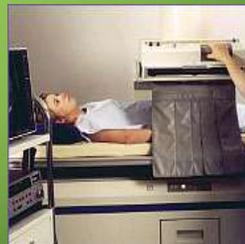
EQUIPMENT SURVEYS

- 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



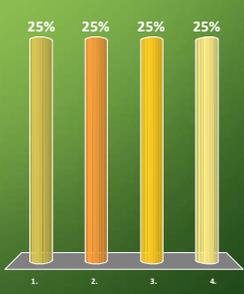
48

REVIEW QUESTIONS

49

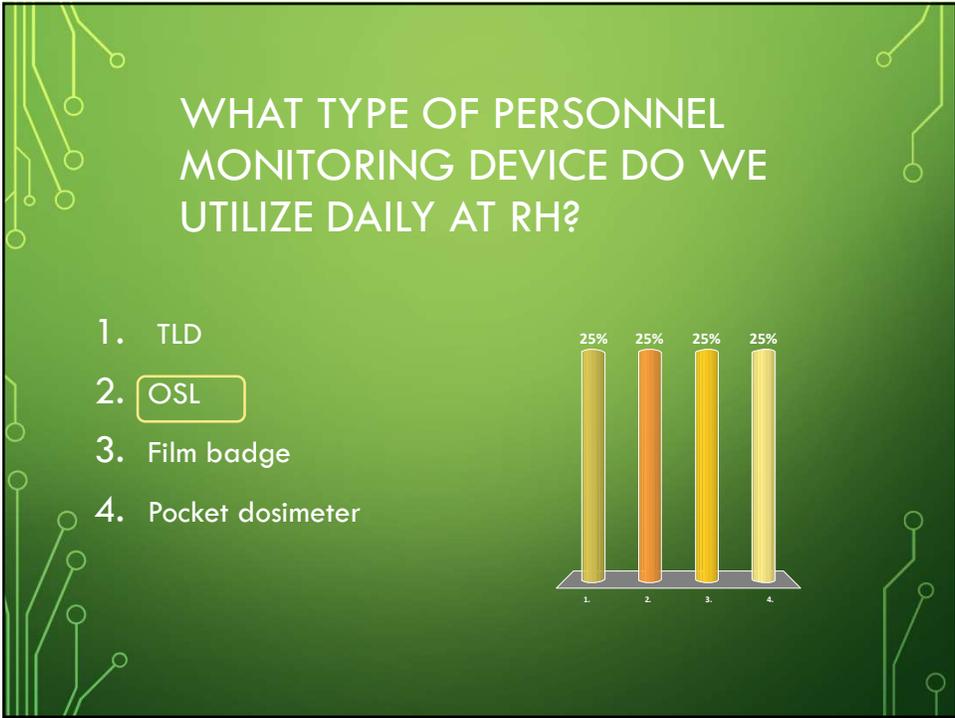
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

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



Option	Percentage
1. Deep dose	25%
2. Shallow dose	25%
3. Eye dose	25%
4. Lens dose	25%

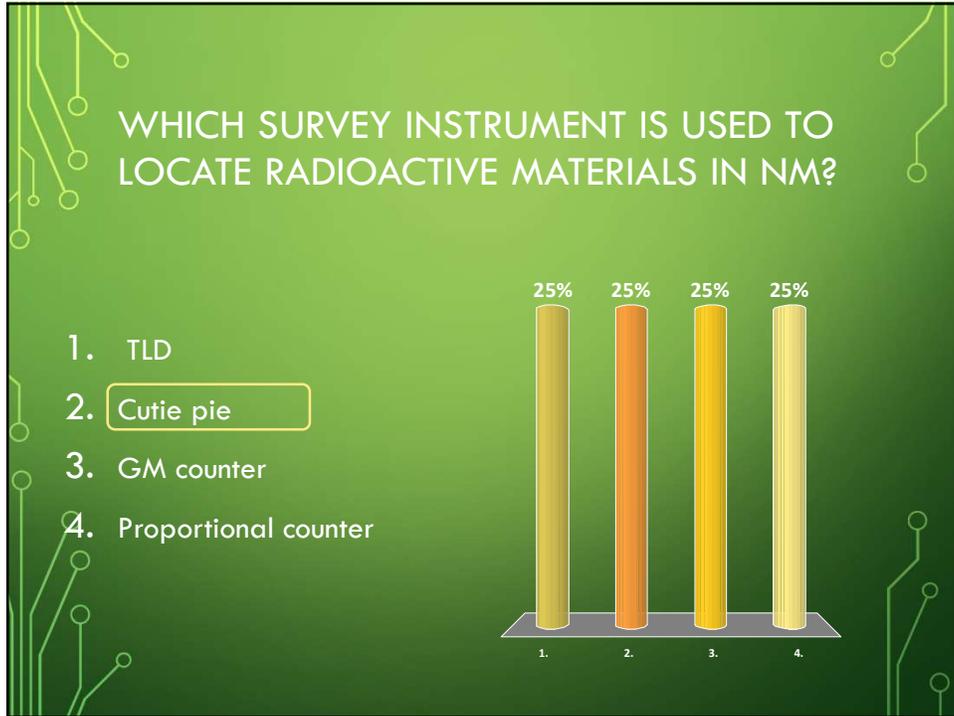
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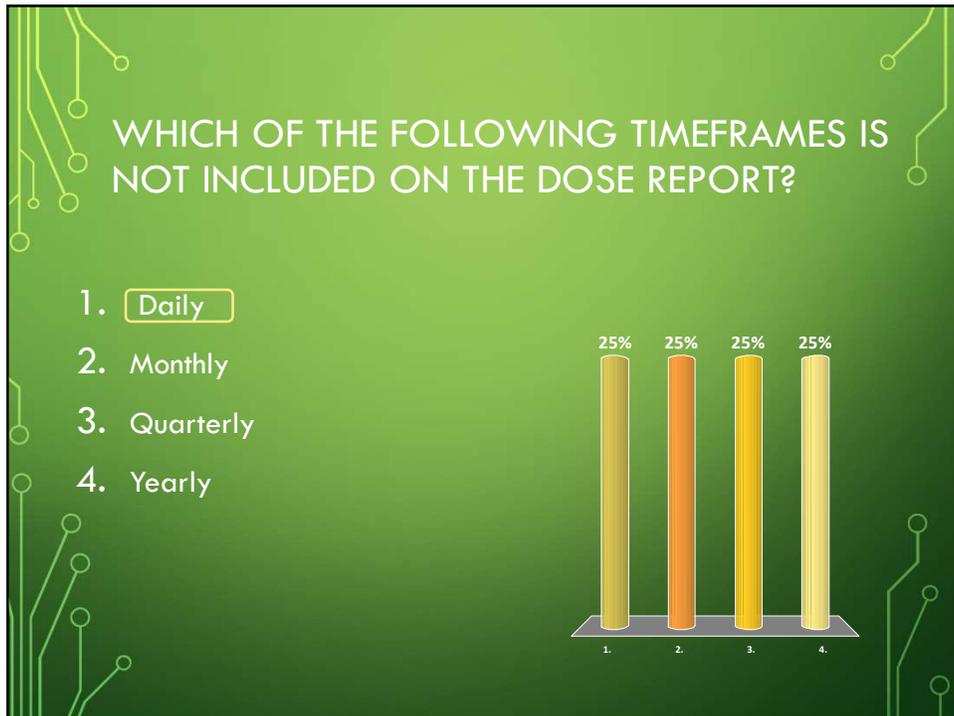
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53



54

WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

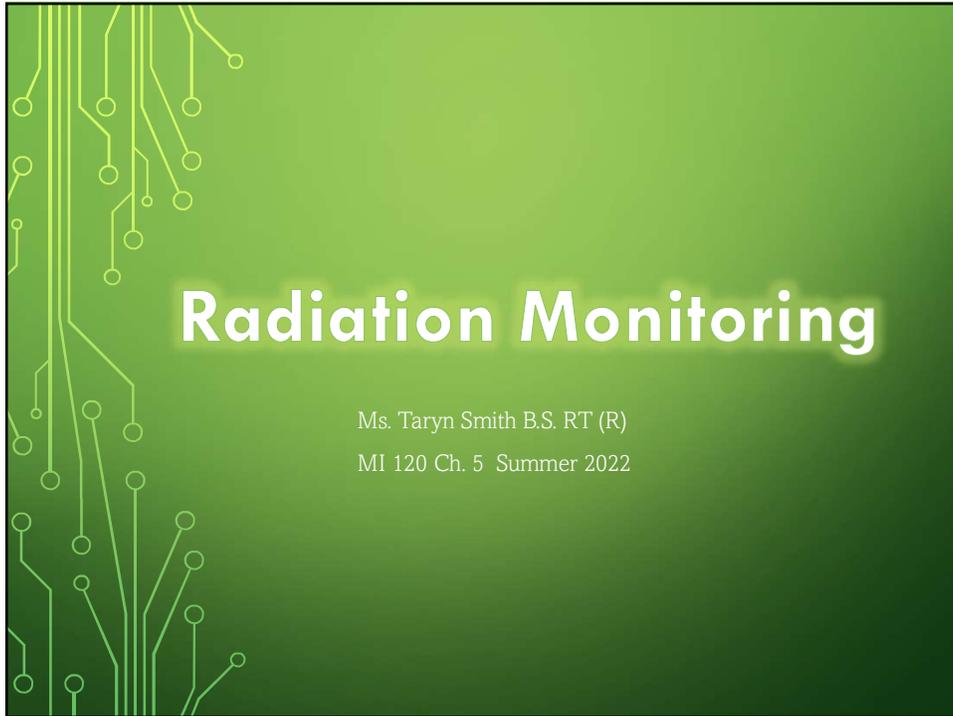
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Sensing Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

56



57



Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

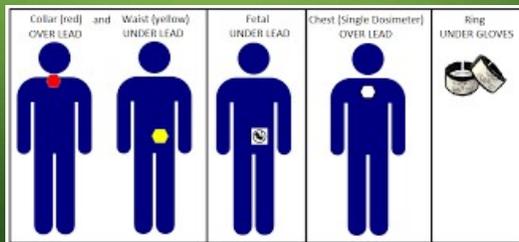


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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 0.1 mGy
 - 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 to be sent out to be read



12

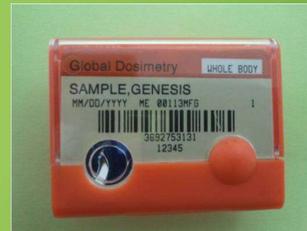
TLD- THERMOLUMINESCENT DOSIMETER

- 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
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TLD DISADVANTAGES

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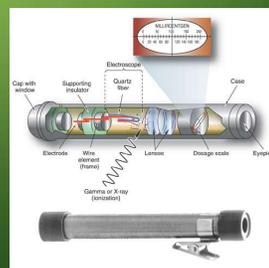
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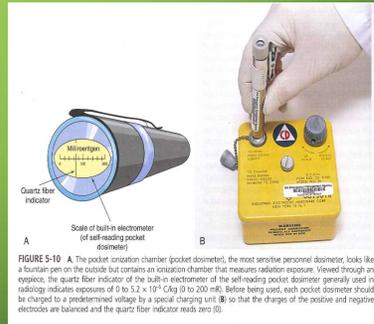
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- Most sensitive
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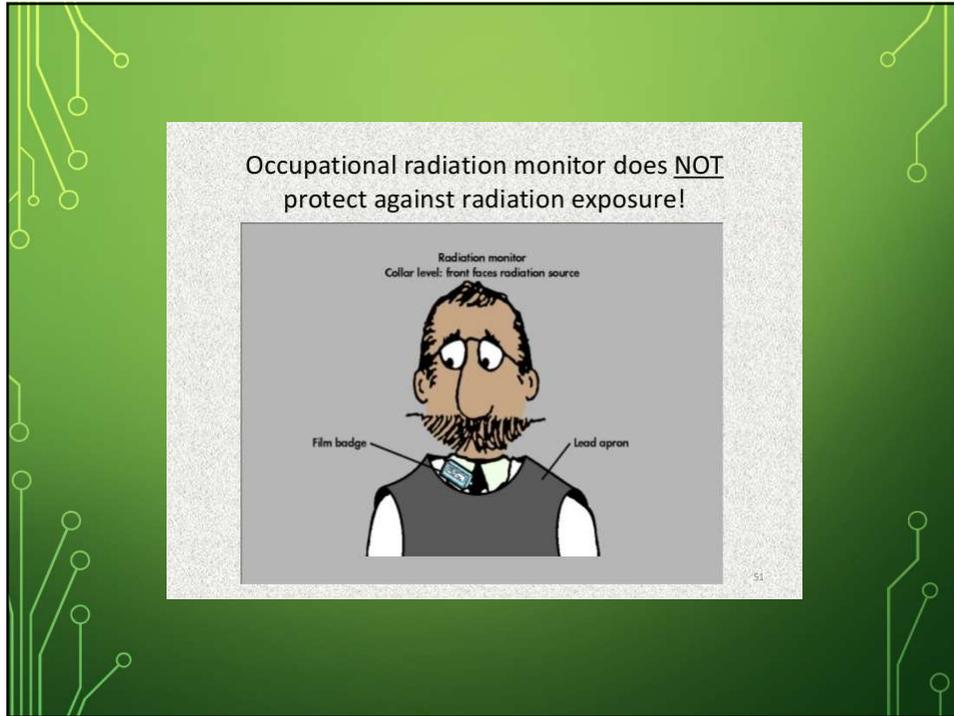
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 - 0.3cm depth in the eye
 - Exposure to the lens

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Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

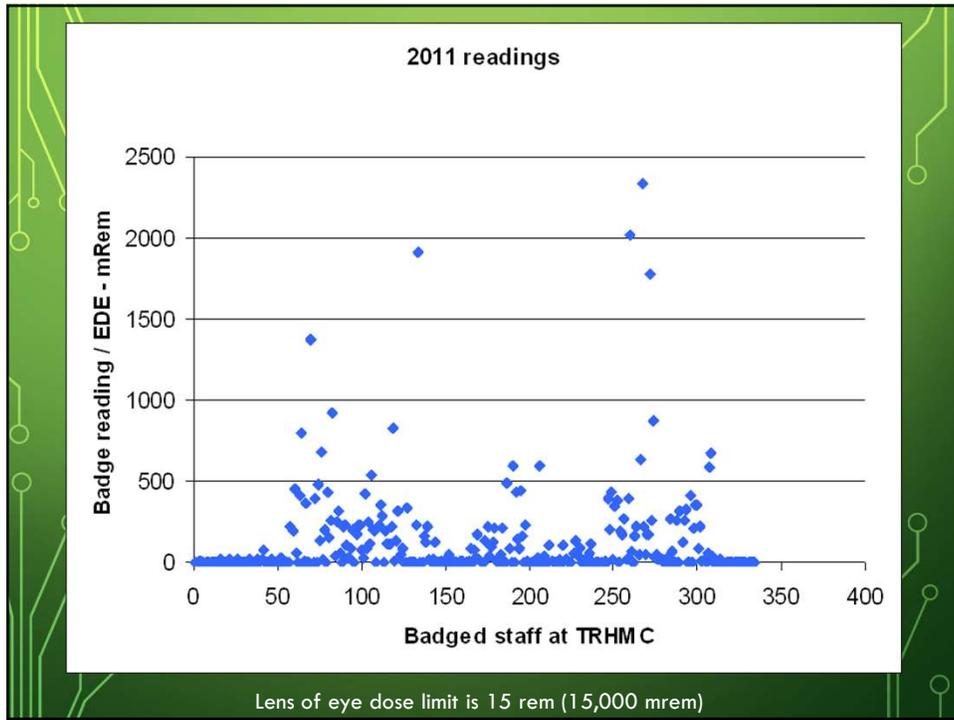
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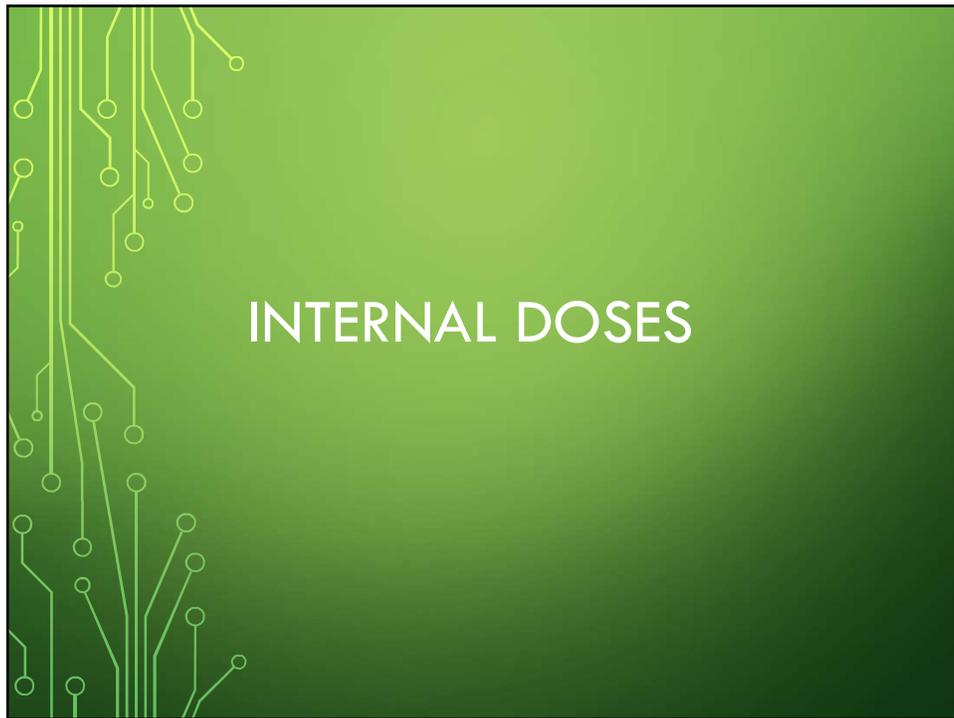
Participant Number	Name	ID Number	Birth Date	Dosimeter	Use	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									Inception Date	Serial Number						
								Period Shown Below			Quarter to Date			Year to Date					Lifetime to Date					
								DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE			DDE	LDE	SDE			
For Monitoring Period: 2022-03-01 to 2023-02-29								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9075484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9075485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9075486L
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33



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

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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

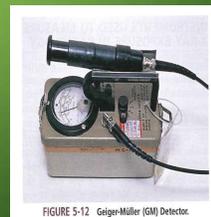


FIGURE 5-12 Geiger-Müller (GM) Detector.

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

44

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 - Power equipment down
- Interlocks
 - Detents
- Visual- audio monitors
 - Timer and audible signal
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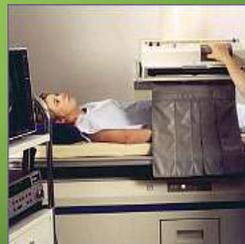
EQUIPMENT SURVEYS

- 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



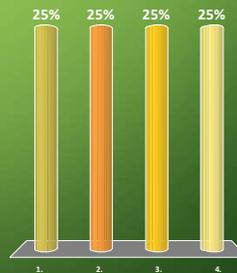
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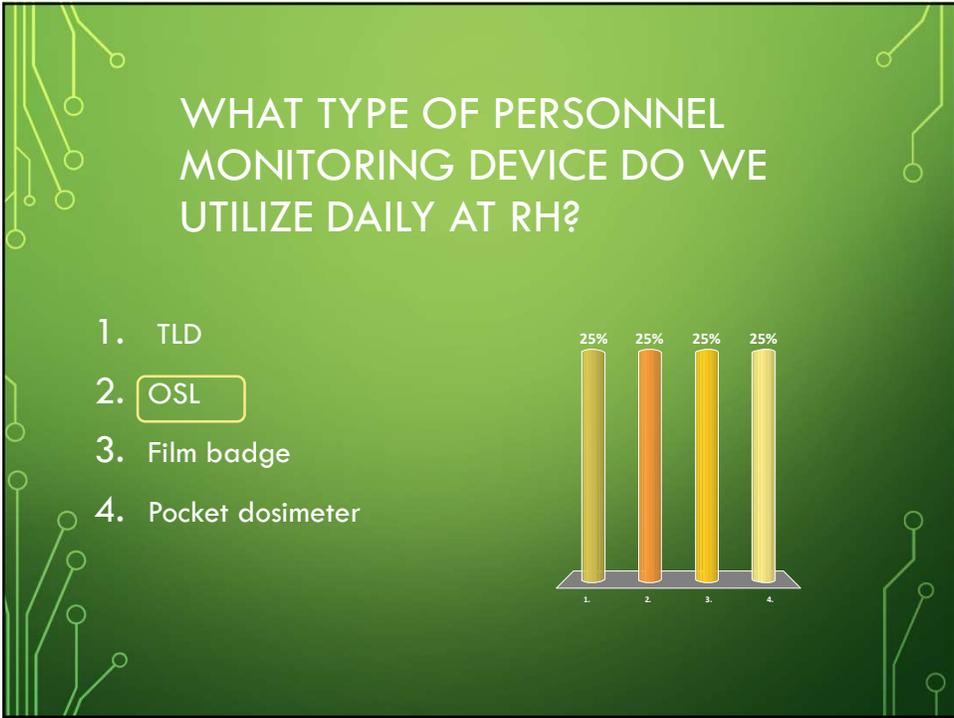
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WHICH DOSE ON THE BADGE REPORT IS
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1. Deep dose
2. Shallow dose
3. Eye dose
4. Lens dose



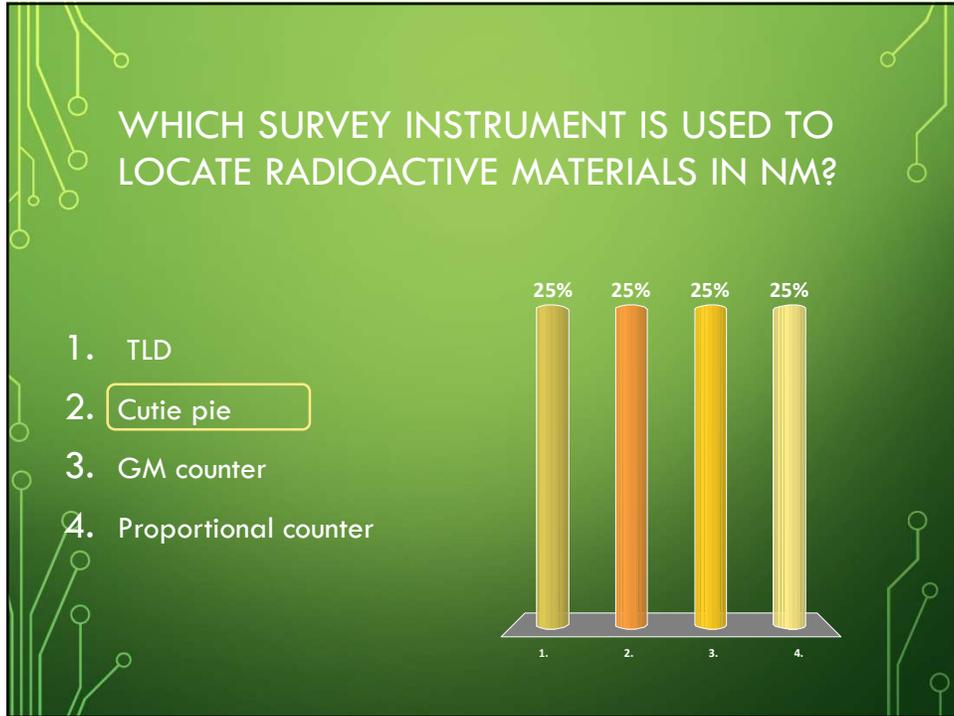
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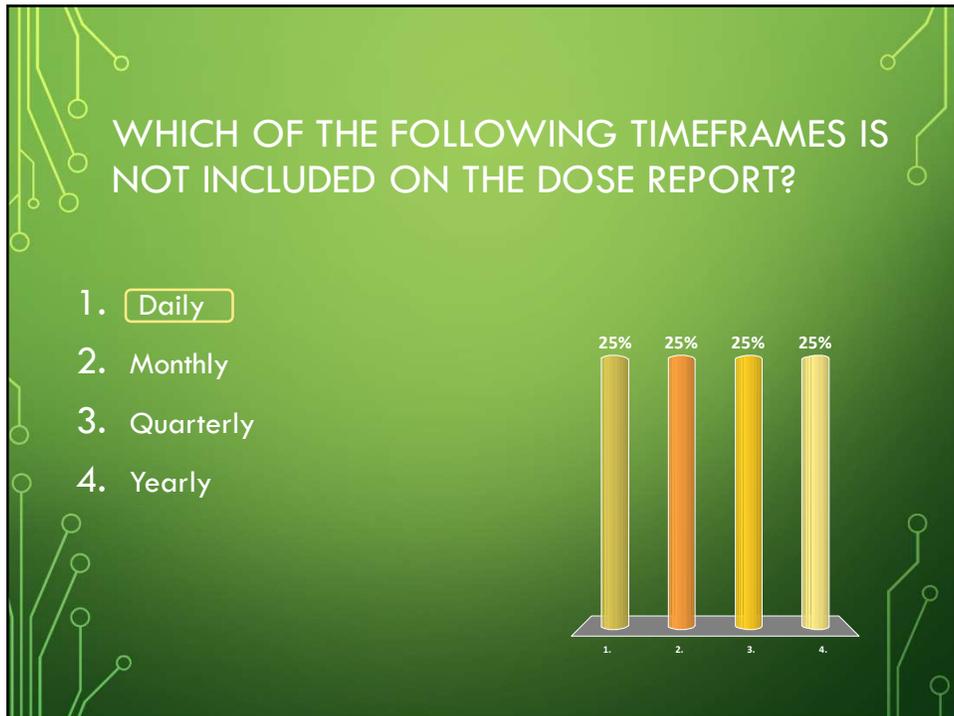
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WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

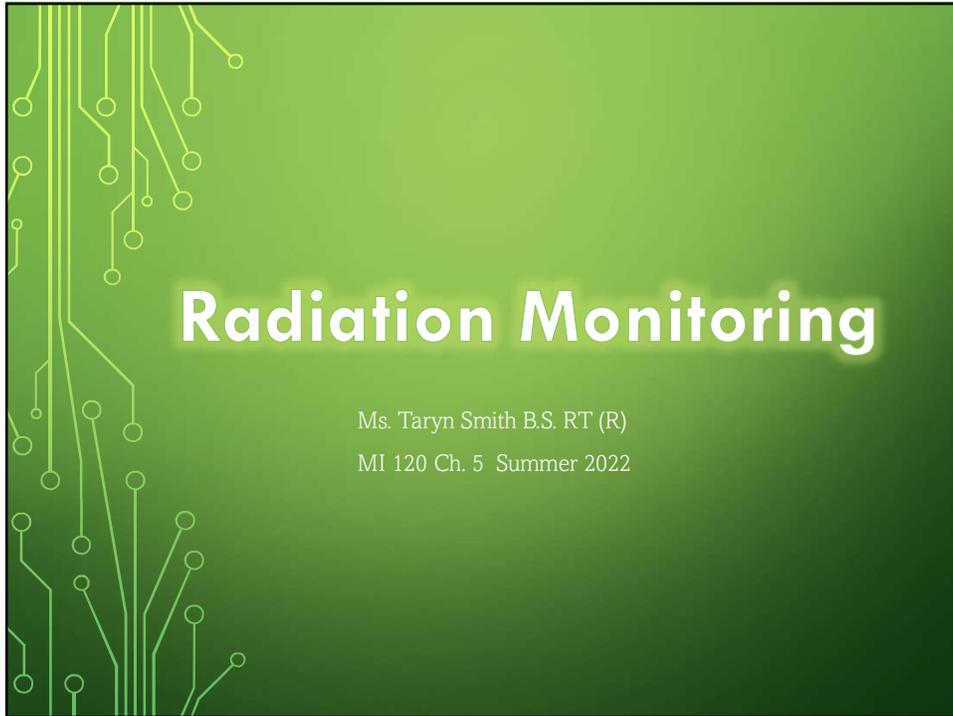
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

56



57



Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

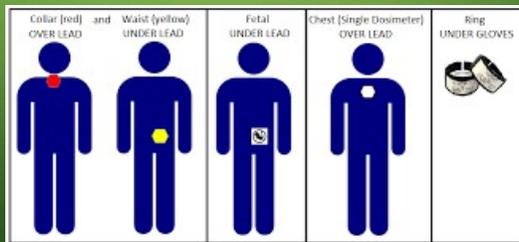


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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 0.1 mGy
 - 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 to be sent out to be read



12

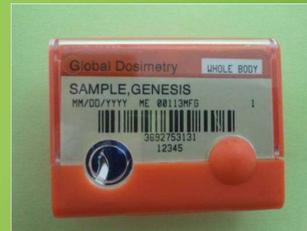
TLD- THERMOLUMINESCENT DOSIMETER

- 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



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TLD ADVANTAGES



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

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TLD DISADVANTAGES

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



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

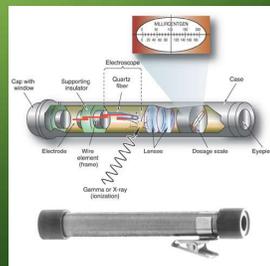
OSL DISADVANTAGES

- 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

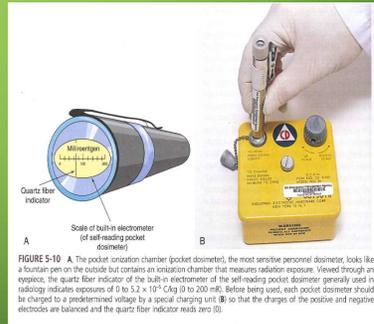
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



20

POCKET IONIZATION CHAMBER ADVANTAGES

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



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

21

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



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	2287700129 / LCA
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Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

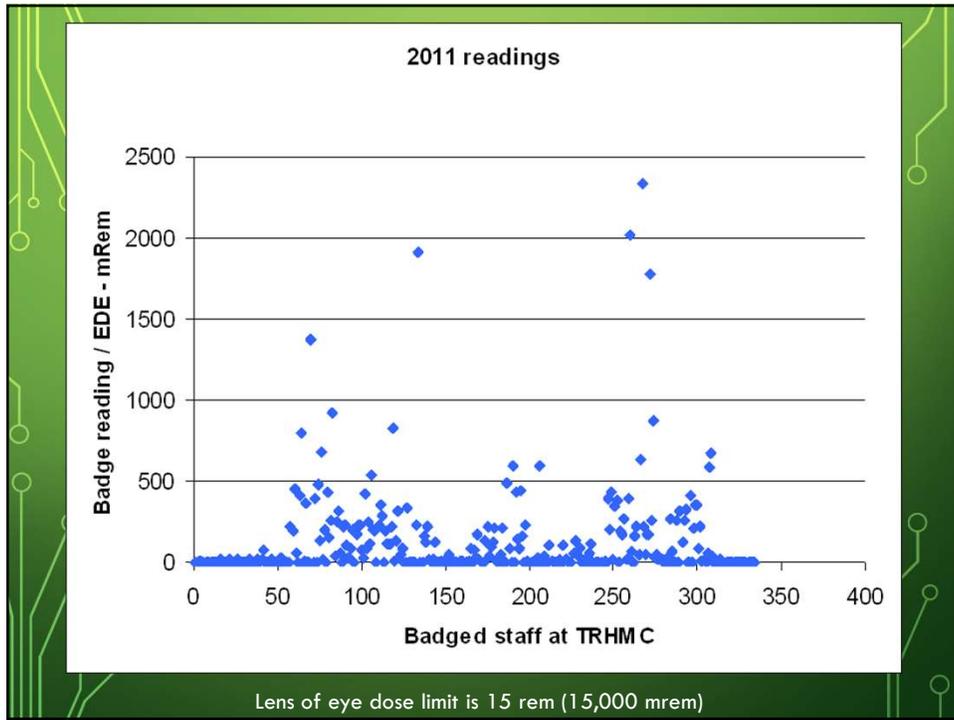
Account : 719 Account: 1456718 Series: SHS

*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.

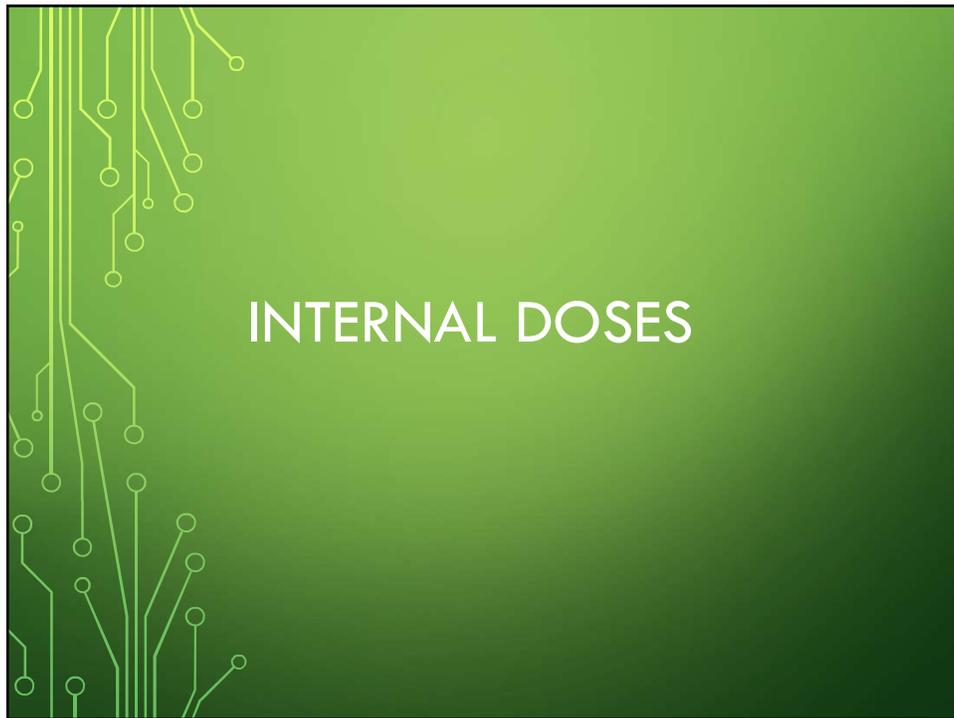
Participant Number	Name	ID Number	Birth Date	Dosimeter	Use	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									Inception Date	Serial Number							
								Period Shown Below			Quarter to Date			Year to Date					Lifetime to Date						
								DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE			DDE	LDE	SDE				
For Monitoring Period: 2022-03-01 to 2022-03-28								QUARTER 1			2022			LIFETIME											
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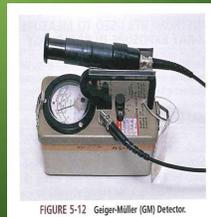


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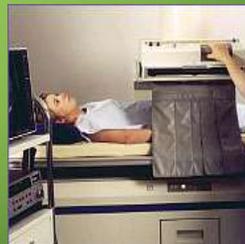
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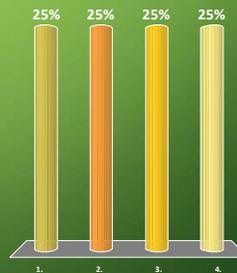
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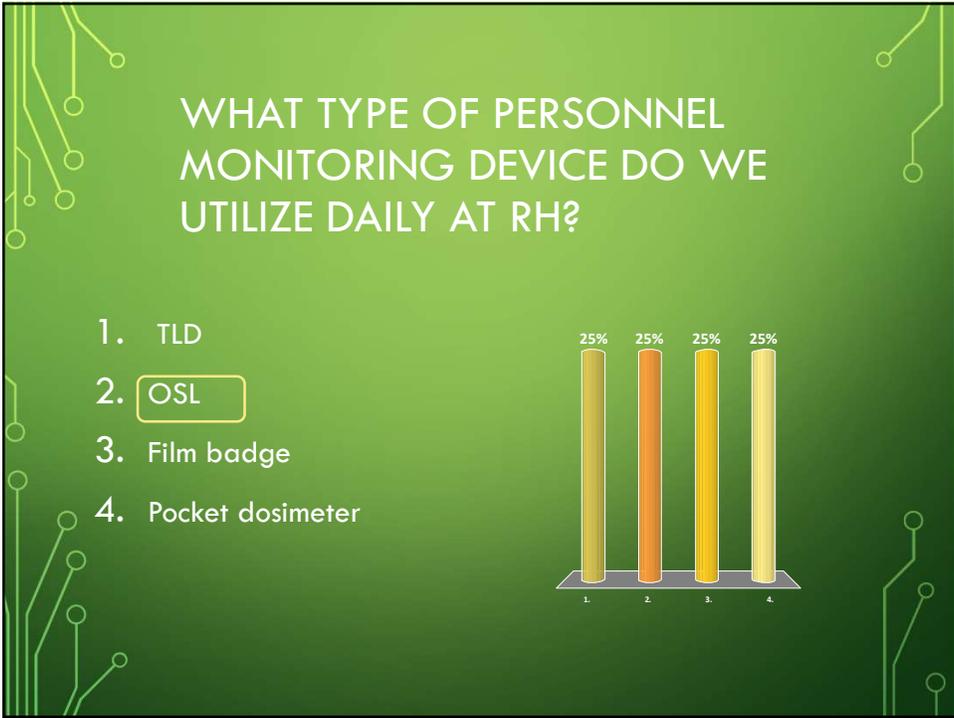
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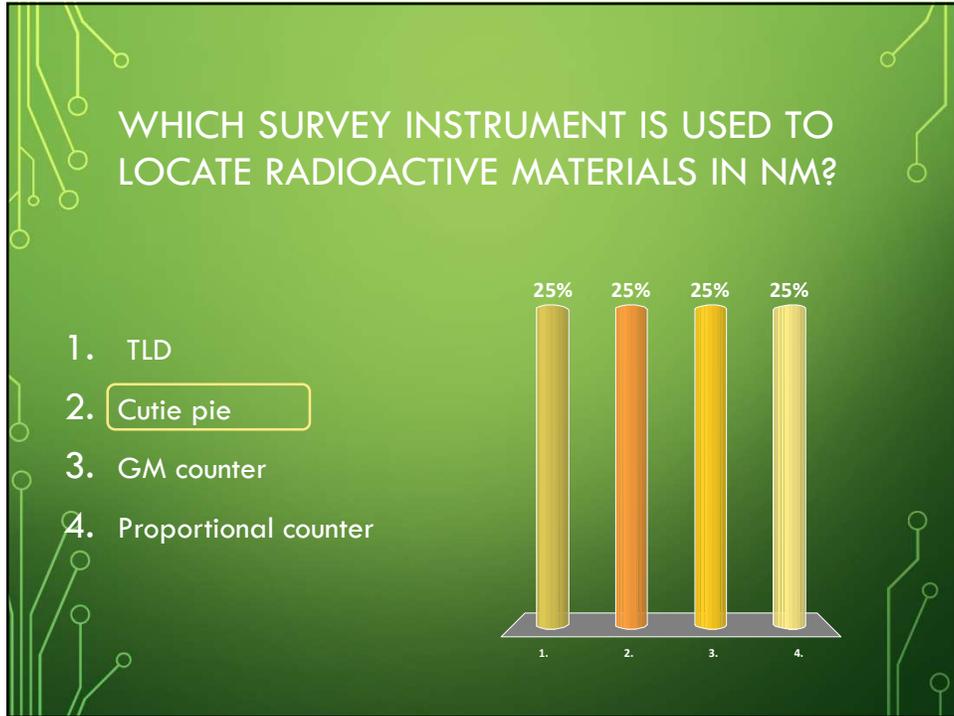
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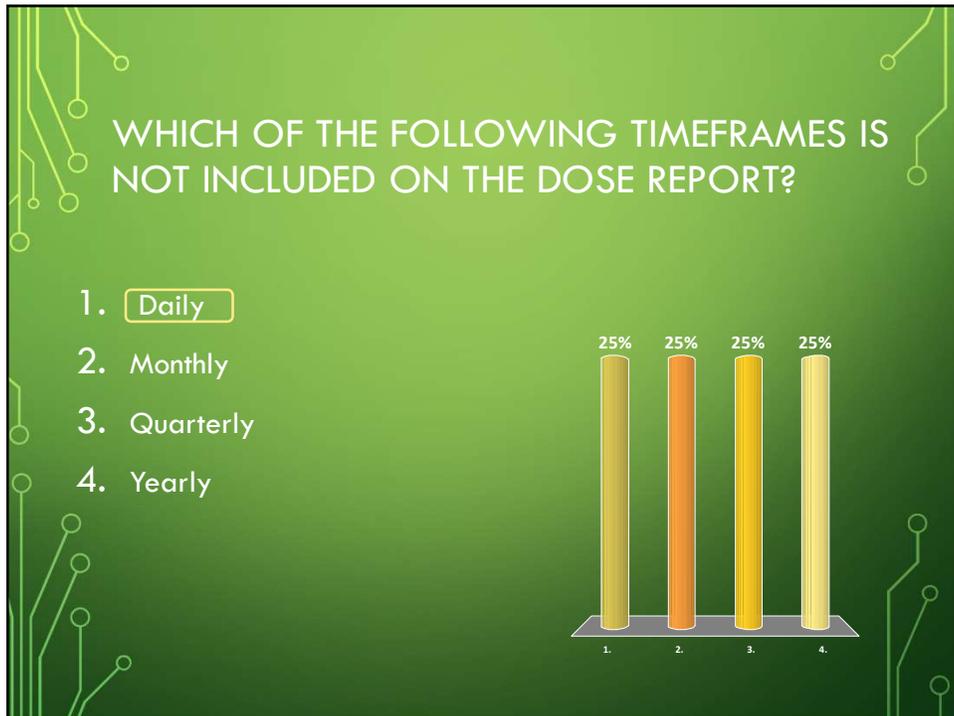
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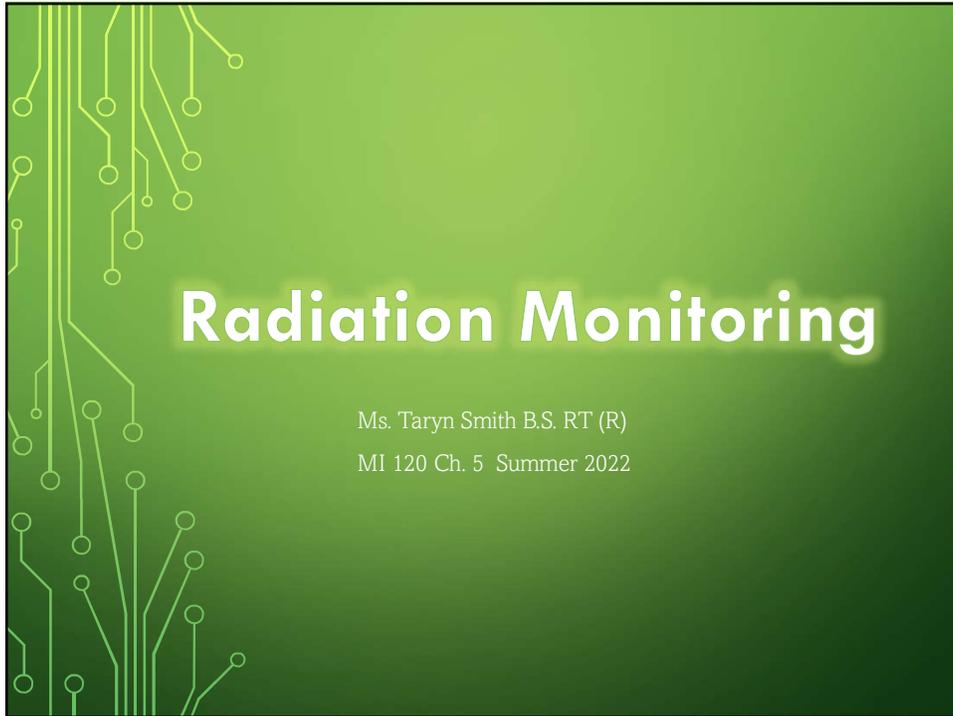
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56



57



Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

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- 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

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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 0.1 mGy
 - 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 to be sent out to be read



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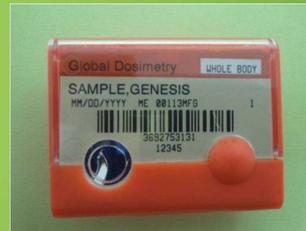
TLD- THERMOLUMINESCENT DOSIMETER

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



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TLD ADVANTAGES



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

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TLD DISADVANTAGES

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



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OSL- OPTICALLY STIMULATED LUMINESCENT DOSIMETER

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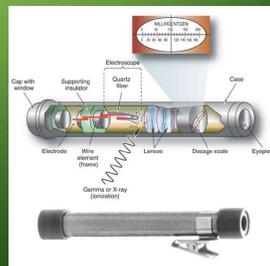
OSL DISADVANTAGES

- 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

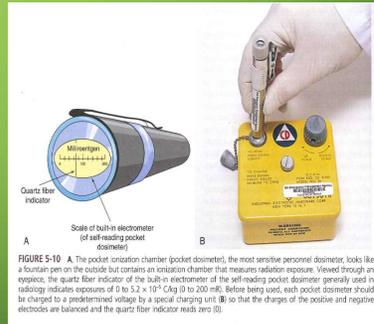
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



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POCKET IONIZATION CHAMBER ADVANTAGES

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



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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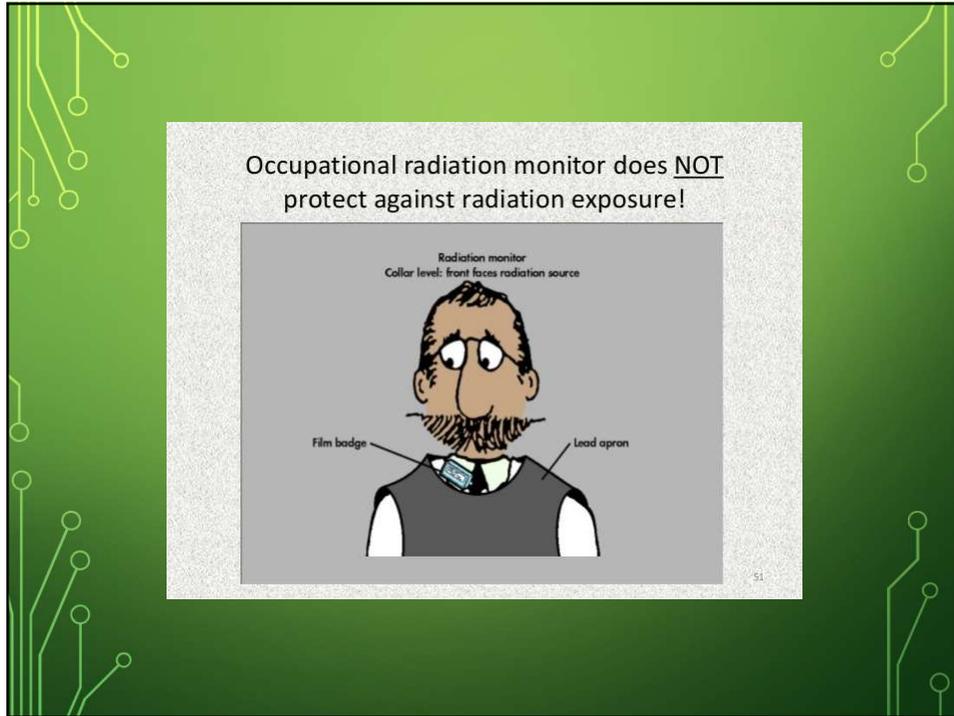
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

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	Range Type 1	Range Type 2	Range Type 3	Range Type 4	Range Type 5 (LUMC & R-22) or 10-100	Range Type 6	Range Type 7	
Personal Dosimeters	Instadose®2	Instadose®	Instadose®	APex™	Genesis Ultra TLD™	Measuring™	Ultra™ & Flex™	
Overview	All the advantages reported of traditional TLDs with measurement for both radon and gamma.	Instadose™ enables repetitive weekly, biweekly, or monthly dose rate, region, work, reporting.	The only available OSL composite dosimeter reading system, suitable for area measurements.	After dosimeter can be re-used multiple times, enabling an individual into several exposures.	Ultra™ offers TLD dosimeters, Genesis Ultra™ offers an improved digital response with steady reading.	Range and frequency dosimeters are ideal for low or high energy beta, X-ray or gamma radon monitoring of hands and fingers.		
Features	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity	• Durable and easy to wear • Dose rate up to 1000 µSv/h • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity • 100% relative humidity
Applications	Requires primarily exposed to occupational radiation. Can also be used for area monitoring.	Requires primarily exposed to occupational radiation. Can also be used for area monitoring.	Requires primarily exposed to occupational radiation. Can also be used for area monitoring.	Requires primarily exposed to occupational radiation. Can also be used for area monitoring.	Requires primarily exposed to occupational radiation. Can also be used for area monitoring.	Individuals handling radionuclides, performing interventional radiographic procedures, or who have higher risk of radiation exposure to their hands and fingers.		
Description	Instadose™ (Type 1) and Instadose™ (Type 2) are based on the latest OSL technology.	Instadose™ (Type 3) is based on the latest OSL technology.	Instadose™ (Type 4) is based on the latest OSL technology.	Instadose™ (Type 5) is based on the latest OSL technology.	Instadose™ (Type 6) is based on the latest OSL technology.	Instadose™ (Type 7) is based on the latest OSL technology.	Instadose™ (Type 8) is based on the latest OSL technology.	
Min. Reportable Dose (MRD) & Useful Dose Range	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	0.05 mSv - 100 mSv 0.05 µSv - 100 µSv	
Energy Response	Photo 1 keV - 6 MeV Beta 0.1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	Photo 1 keV - 6 MeV	
Accreditations	US NIST (see code 100001-0) NIST other countries	US NIST (see code 100001-0) NIST other countries	US NIST (see code 100001-0) NIST other countries	US NIST (see code 100001-0) NIST other countries	US NIST (see code 100001-0) NIST other countries	US NIST (see code 100001-0) NIST other countries	US NIST (see code 100001-0) NIST other countries	
Holder Type Prog. size and measurement and response.								

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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	2287700129 / LCA
Copy / Version	0 / 1



NVLAP LAB CODE 105518-0

LANDAUER[®]
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landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 Account: 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	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									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: 2022-03-01 to 2023-02-28								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9975485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
00714	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9975487L
00720	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9975488L
00725	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9975489L
00737	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9975490L

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 (mSv)

Whole Body, Most Sensitive Organs, Adults	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Pregnant female)	500
General Public	100

Based on the 10 NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may address or otherwise limit.

Dosimeter Description: A dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during work. At the customer's facility, when the dosimeter is in a radiation-free area during the work period.

Minimal Dose Equivalent Reported: Dose measurements below the minimum measurable quantity for the current monitoring period are reported as "0". The normal reporting mode may be the dosimeter low and minimum quantity, "0", to an active signal for the minimal dose equivalent reported when exposures less than 10 mrem report as "0". Includes total dose equivalent, and/or exposures of more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (DOSE, DSE, DDE)	M (DOSE Only)	SL
Low-E	1	-	10
High-E	5	-	50
Whole Body Low-E	-	10	10
LI Ring	-	30	-
Neutron Monitor Feet	10	-	-
Neutron Monitor Feet	10	-	-
Scout Ring	-	10	10

Special Considerations: Dosimeter calibration can be applied by radiation workers who wear lead aprons.

DOSE 1: Low dosimeters use silver or the metal foil under lead apron and use wear at the collar level outside lead apron. 1.0 (Mant DDE) = 0.04 (Collar DDE) = Assigned Dose Equivalent.

DOSE 2: Low dosimeter: one worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Dose Equivalent.

DOSE 12: Low dosimeter: one worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

DOSE 15: Assigned Deep Dose Equivalent.

Collar: Lens of Eye Dosimeter: 0.3 Lens of Eye DDE = Assigned Lens of Eye Dose Equivalent.

Lens: Lens of Eye Dosimeter: 0.175 Lens of Eye DDE = Assigned Lens of Eye Dose Equivalent.

DOSE 16: ATC DDE without Thyroid Collar assigned deep dose equivalent = 0.04 = collar dose = wrist dose = wrist dose

DOSE 17: ATC DDE with Thyroid Collar assigned deep dose equivalent = 0.04 = collar dose = wrist dose = wrist dose

DOSE 18: ATC DDE with Thyroid Collar assigned deep dose equivalent = 0.04 = collar dose = wrist dose = wrist dose

The "ASSIGNED" dose values are the original whole body dosimeter doses with the EYE 1 or EYE 2 calibration results in LANDAUER's standard Dose Assessment Protocol group and studies whole body dose from the highest reading whole body dosimeter, less than from dosimeter located to the eye).

Ring Dosimeter Readings: Ring dosimeter readings report at a shallow dose.

Fetal Dosimeter: A dosimeter program marker will assume a fetal exposure on all data pages of the report. Contact your local body dosimeter agent to obtain the fetal dose. The fetal dose is reported for the current work period. Also the estimated dose from conception to dosimeter (if provided by customer), and the total dose from conception to present.

Use	Description	Use	Description
AREA	Area Monitor	CESTRM	Chest Extremity
CHGRT	Chest	DWGRDY	Other Whole Body
CTRLC	Control	FINSLC	Right Arm
DCLLAH	Collar	AFGRJG	Right Hand/Thng
EYE	Eye	HEAMR	Right Upper Arm
FETAL	Fetal	FLLEDG	Right Upper Leg
LEADLE	Lead Shield	BWNGST	Right Hand
LFRADR	Left Hand Ring	DFCPHR	Special Purpose
LFRARM	Left Upper Arm	DFBACR	Upper Back
LLELDG	Left Upper Leg	WABT	Wrist
LWBACR	Lower Back	WBWDY	Whole Body
LWRIST	Left Wrist		

Code	Radiation Quality Description (Type and Energy)
B	beta
BE	beta high energy, e.g. Thorium, Protactinium
BL	beta low energy e.g. Thallium, Tritium
BS	bremsstrahlung
BT	Thallium beta
BU	Uranium beta
DF	beta, neutron mixture
HF	neutron fast
HT	neutron thermal
P	positron (or gamma ray)
FB	positron, beta mixture
PMN	positron, beta, neutron mixture
PH	positron high energy greater than 200 keV
PL	positron low energy less than 40 keV
PH	positron medium energy 40 keV to 200 keV
PG	positron, neutron mixture

First 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	Fast	Thermal	Other
High-Energy	100000	Yes	Yes	Yes	Yes	Yes
Low-Energy	100001	Yes	Yes	Yes	Yes	Yes
Low-Energy	100002	Yes	Yes	Yes	Yes	Yes
Low-Energy	100003	Yes	Yes	Yes	Yes	Yes
Low-Energy	100004	Yes	Yes	Yes	Yes	Yes
Low-Energy	100005	Yes	Yes	Yes	Yes	Yes
Low-Energy	100006	Yes	Yes	Yes	Yes	Yes
Low-Energy	100007	Yes	Yes	Yes	Yes	Yes
Low-Energy	100008	Yes	Yes	Yes	Yes	Yes
Low-Energy	100009	Yes	Yes	Yes	Yes	Yes
Low-Energy	100010	Yes	Yes	Yes	Yes	Yes
Low-Energy	100011	Yes	Yes	Yes	Yes	Yes
Low-Energy	100012	Yes	Yes	Yes	Yes	Yes
Low-Energy	100013	Yes	Yes	Yes	Yes	Yes
Low-Energy	100014	Yes	Yes	Yes	Yes	Yes
Low-Energy	100015	Yes	Yes	Yes	Yes	Yes
Low-Energy	100016	Yes	Yes	Yes	Yes	Yes
Low-Energy	100017	Yes	Yes	Yes	Yes	Yes
Low-Energy	100018	Yes	Yes	Yes	Yes	Yes
Low-Energy	100019	Yes	Yes	Yes	Yes	Yes
Low-Energy	100020	Yes	Yes	Yes	Yes	Yes
Low-Energy	100021	Yes	Yes	Yes	Yes	Yes
Low-Energy	100022	Yes	Yes	Yes	Yes	Yes
Low-Energy	100023	Yes	Yes	Yes	Yes	Yes
Low-Energy	100024	Yes	Yes	Yes	Yes	Yes
Low-Energy	100025	Yes	Yes	Yes	Yes	Yes
Low-Energy	100026	Yes	Yes	Yes	Yes	Yes
Low-Energy	100027	Yes	Yes	Yes	Yes	Yes
Low-Energy	100028	Yes	Yes	Yes	Yes	Yes
Low-Energy	100029	Yes	Yes	Yes	Yes	Yes
Low-Energy	100030	Yes	Yes	Yes	Yes	Yes
Low-Energy	100031	Yes	Yes	Yes	Yes	Yes
Low-Energy	100032	Yes	Yes	Yes	Yes	Yes
Low-Energy	100033	Yes	Yes	Yes	Yes	Yes
Low-Energy	100034	Yes	Yes	Yes	Yes	Yes
Low-Energy	100035	Yes	Yes	Yes	Yes	Yes
Low-Energy	100036	Yes	Yes	Yes	Yes	Yes
Low-Energy	100037	Yes	Yes	Yes	Yes	Yes
Low-Energy	100038	Yes	Yes	Yes	Yes	Yes
Low-Energy	100039	Yes	Yes	Yes	Yes	Yes
Low-Energy	100040	Yes	Yes	Yes	Yes	Yes
Low-Energy	100041	Yes	Yes	Yes	Yes	Yes
Low-Energy	100042	Yes	Yes	Yes	Yes	Yes
Low-Energy	100043	Yes	Yes	Yes	Yes	Yes
Low-Energy	100044	Yes	Yes	Yes	Yes	Yes
Low-Energy	100045	Yes	Yes	Yes	Yes	Yes
Low-Energy	100046	Yes	Yes	Yes	Yes	Yes
Low-Energy	100047	Yes	Yes	Yes	Yes	Yes
Low-Energy	100048	Yes	Yes	Yes	Yes	Yes
Low-Energy	100049	Yes	Yes	Yes	Yes	Yes
Low-Energy	100050	Yes	Yes	Yes	Yes	Yes
Low-Energy	100051	Yes	Yes	Yes	Yes	Yes
Low-Energy	100052	Yes	Yes	Yes	Yes	Yes
Low-Energy	100053	Yes	Yes	Yes	Yes	Yes
Low-Energy	100054	Yes	Yes	Yes	Yes	Yes
Low-Energy	100055	Yes	Yes	Yes	Yes	Yes
Low-Energy	100056	Yes	Yes	Yes	Yes	Yes
Low-Energy	100057	Yes	Yes	Yes	Yes	Yes
Low-Energy	100058	Yes	Yes	Yes	Yes	Yes
Low-Energy	100059	Yes	Yes	Yes	Yes	Yes
Low-Energy	100060	Yes	Yes	Yes	Yes	Yes
Low-Energy	100061	Yes	Yes	Yes	Yes	Yes
Low-Energy	100062	Yes	Yes	Yes	Yes	Yes
Low-Energy	100063	Yes	Yes	Yes	Yes	Yes
Low-Energy	100064	Yes	Yes	Yes	Yes	Yes
Low-Energy	100065	Yes	Yes	Yes	Yes	Yes
Low-Energy	100066	Yes	Yes	Yes	Yes	Yes
Low-Energy	100067	Yes	Yes	Yes	Yes	Yes
Low-Energy	100068	Yes	Yes	Yes	Yes	Yes
Low-Energy	100069	Yes	Yes	Yes	Yes	Yes
Low-Energy	100070	Yes	Yes	Yes	Yes	Yes
Low-Energy	100071	Yes	Yes	Yes	Yes	Yes
Low-Energy	100072	Yes	Yes	Yes	Yes	Yes
Low-Energy	100073	Yes	Yes	Yes	Yes	Yes
Low-Energy	100074	Yes	Yes	Yes	Yes	Yes
Low-Energy	100075	Yes	Yes	Yes	Yes	Yes
Low-Energy	100076	Yes	Yes	Yes	Yes	Yes
Low-Energy	100077	Yes	Yes	Yes	Yes	Yes
Low-Energy	100078	Yes	Yes	Yes	Yes	Yes
Low-Energy	100079	Yes	Yes	Yes	Yes	Yes
Low-Energy	100080	Yes	Yes	Yes	Yes	Yes
Low-Energy	100081	Yes	Yes	Yes	Yes	Yes
Low-Energy	100082	Yes	Yes	Yes	Yes	Yes
Low-Energy	100083	Yes	Yes	Yes	Yes	Yes
Low-Energy	100084	Yes	Yes	Yes	Yes	Yes
Low-Energy	100085	Yes	Yes	Yes	Yes	Yes
Low-Energy	100086	Yes	Yes	Yes	Yes	Yes
Low-Energy	100087	Yes	Yes	Yes	Yes	Yes
Low-Energy	100088	Yes	Yes	Yes	Yes	Yes
Low-Energy	100089	Yes	Yes	Yes	Yes	Yes
Low-Energy	100090	Yes	Yes	Yes	Yes	Yes
Low-Energy	100091	Yes	Yes	Yes	Yes	Yes
Low-Energy	100092	Yes	Yes	Yes	Yes	Yes
Low-Energy	100093	Yes	Yes	Yes	Yes	Yes
Low-Energy	100094	Yes	Yes	Yes	Yes	Yes
Low-Energy	100095	Yes	Yes	Yes	Yes	Yes
Low-Energy	100096	Yes	Yes	Yes	Yes	Yes
Low-Energy	100097	Yes	Yes	Yes	Yes	Yes
Low-Energy	100098	Yes	Yes	Yes	Yes	Yes
Low-Energy	100099	Yes	Yes	Yes	Yes	Yes
Low-Energy	100100	Yes	Yes	Yes	Yes	Yes

Dose, Eye and Shallow Dose Equivalents: Deep dose equivalent (DDE) applies to external whole body exposure at a dose depth of 1 cm (DDE report). Eye dose equivalent (EDE) applies to external exposure of the lens at a dose depth of 0.3 cm (EDE report). Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a dose depth of 0.007 cm ("finger", average skin on area 1 cm).

Dose, Eye and Shallow Dose Equivalents: Report for the time frame indicated by the Monitoring Period. These doses represent the dose received only to the measurement specified. Individual calculation component results and combined totals report in separate form.

Quarterly accumulated results: reflect total dose received within a quarterly 3-month time frame and the customer defined start day. Quarterly accumulated results are generated for quarterly service or display. Total applicable 3-year or date equivalent total dose received from the beginning of the current year to report date. Lifetime accumulated total dose received from inception date of dosimeter service to report date, and total include entire dose history if available to customer. Reported quarterly annual and lifetime dose accumulations represent the dose history from all measurement/accumulation instruments to be reported at the customer level.

Receipt Date: The date LANDAUER began keeping dosimeter records for a given dosimeter for a badge purchased on the current customer.

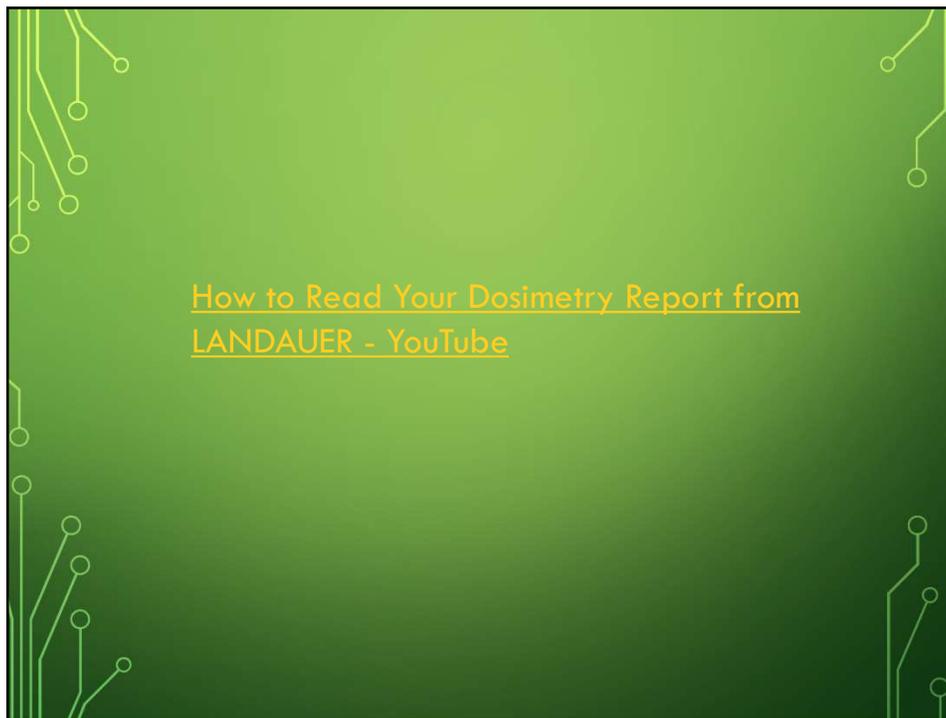
Serial Number: Dosimeter part number.

Second 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.

Notes: Text messages explaining any abnormalities or concerns. The badge with the lowest activity of a badge is the lowest dose badge.

SL, Patient:
SL: Patient
SL: Patient

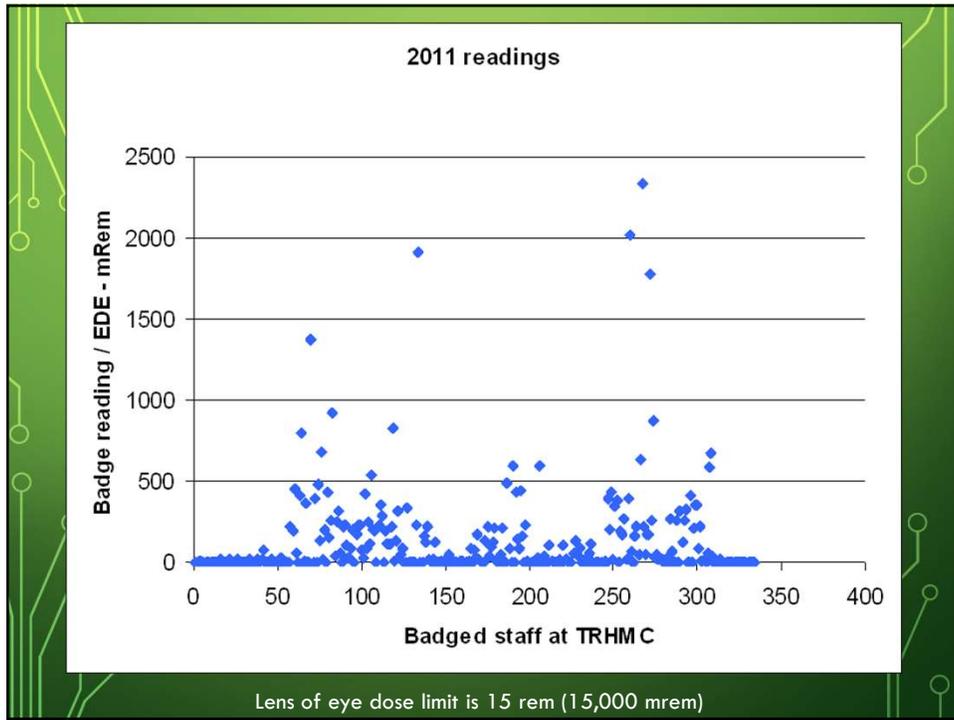
31



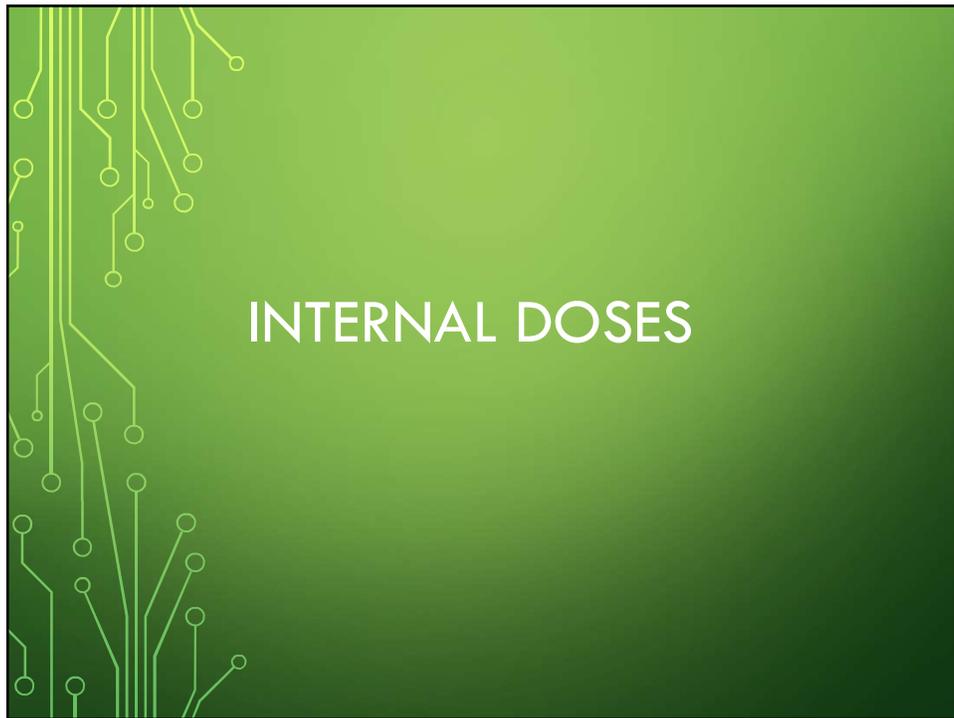
How to Read Your Dosimetry Report from LANDAUER - YouTube

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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.....

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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

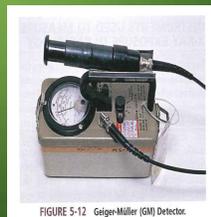


FIGURE 5-12 Geiger-Müller (GM) Detector.

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%



46

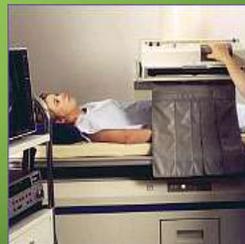
EQUIPMENT SURVEYS

- 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

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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



48

REVIEW QUESTIONS

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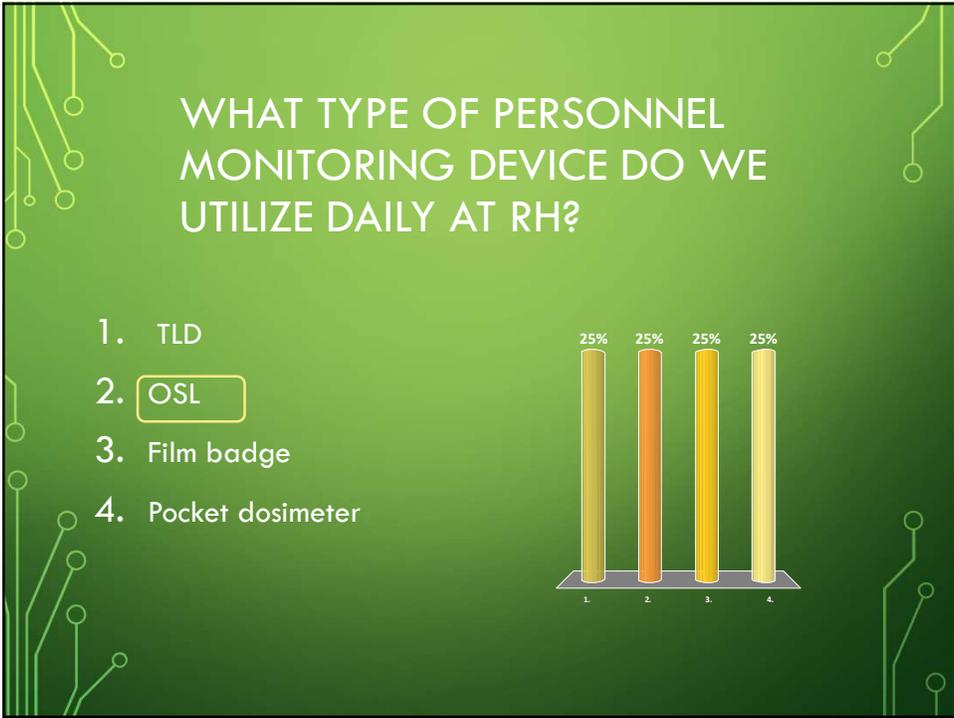
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

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

A bar chart with four bars, each labeled '25%' above it. The bars are numbered 1, 2, 3, and 4 from left to right. The bars are colored in a gradient from light yellow to light orange.

Option	Percentage
1. Deep dose	25%
2. Shallow dose	25%
3. Eye dose	25%
4. Lens dose	25%

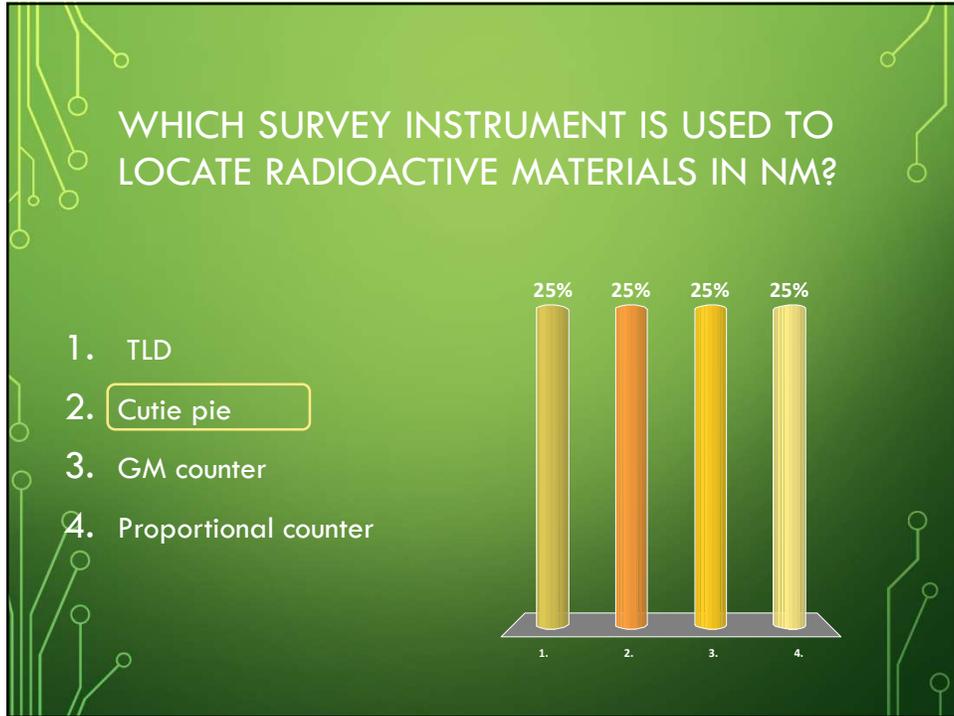
50



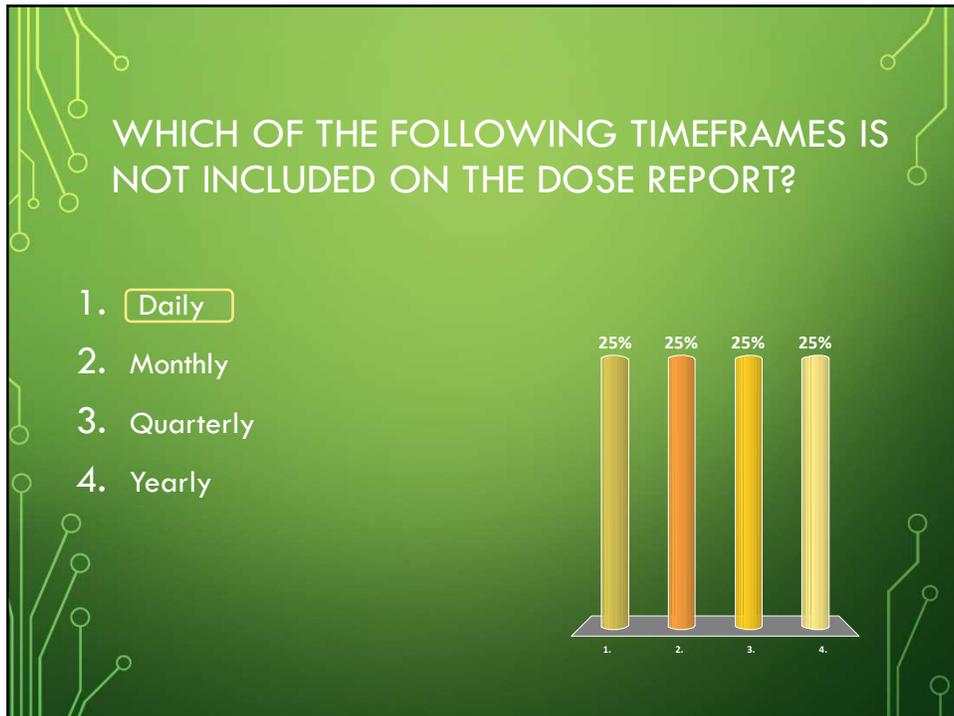
51



52



53



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WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

55

WHAT IS THE SENSING MATERIAL IN A TLD?

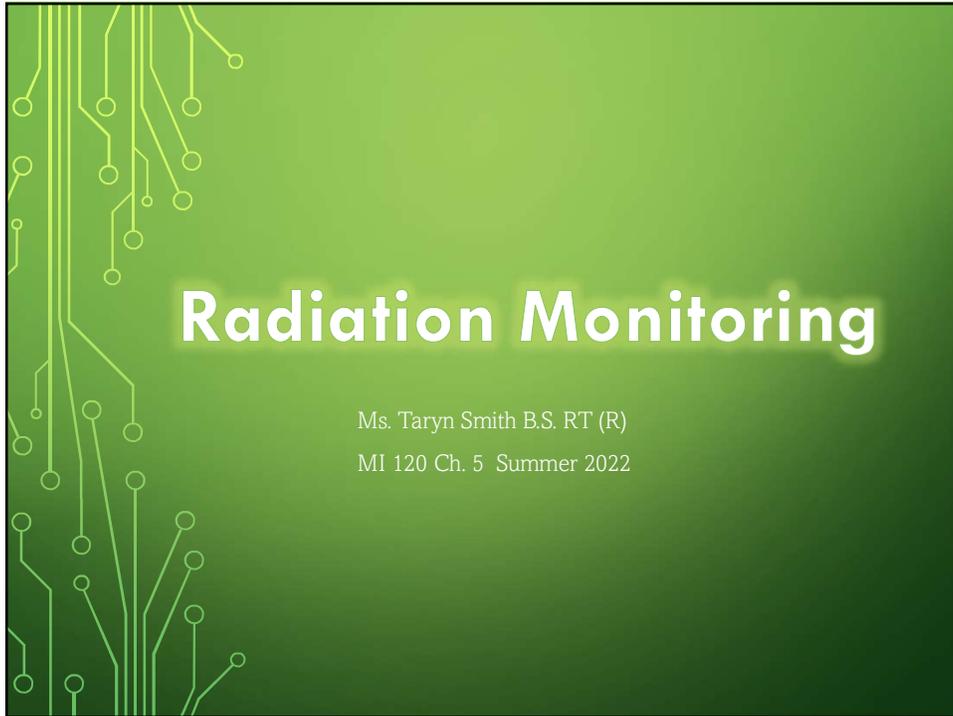
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

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Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

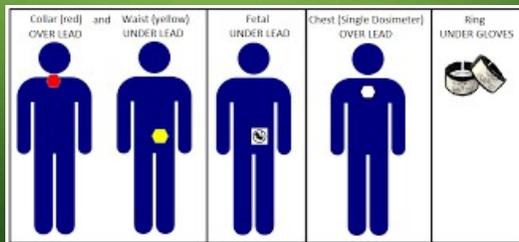


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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



8

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 0.1 mGy
 - 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 to be sent out to be read



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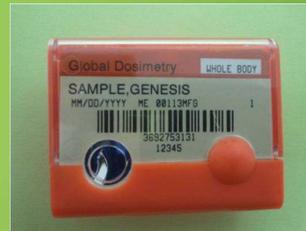
TLD- THERMOLUMINESCENT DOSIMETER

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



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TLD ADVANTAGES



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

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TLD DISADVANTAGES

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



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OSL- OPTICALLY STIMULATED LUMINESCENT DOSIMETER

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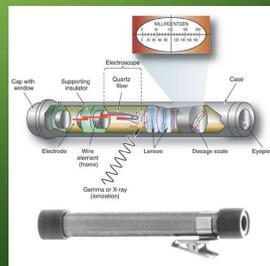
OSL DISADVANTAGES

- 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

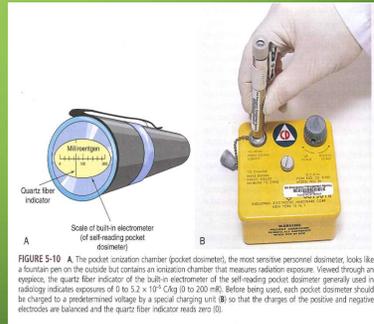


FIGURE 5-10 A, The pocket ionization chamber (pocket dosimeter), the most sensitive personnel dosimeter, looks like a fountain pen on the outside but contains an ionization chamber that measures radiation exposure. Viewed through an eyepiece, the quartz fiber indicator of the built-in electrometer of 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



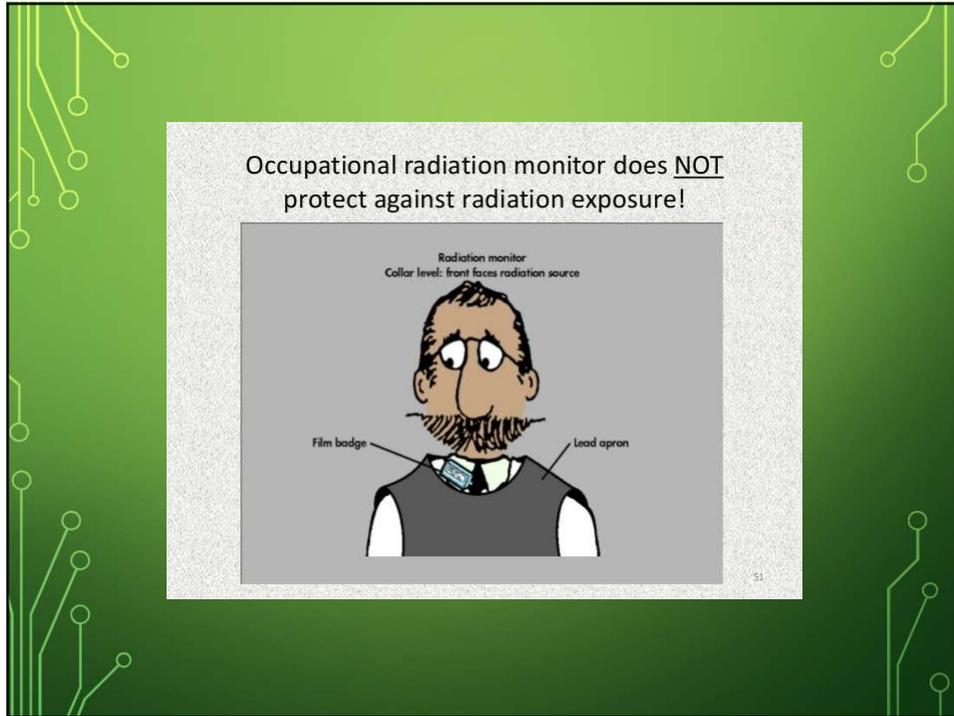
Radiation Protection in Medical Radiography, 9th Ed. Statkiewicz Sherer

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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

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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	2287700129 / LCA
Copy / Version	0 / 1

NVLAP
TESTING
NVLAP LAB CODE 105518-0

LANDAUER
LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

Account : 719 Account: 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	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									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: 2022-03-01 to 2022-03-28								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9975489L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9975485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9975486L
00714	COLLAR			Pa	COLLAR			Assigned dose based on EDE2 Calculation									2018/01	9975487L						
00720	COLLAR			Pa	COLLAR			Assigned dose based on EDE2 Calculation									2018/01	9975488L						
00725	COLLAR			Pa	COLLAR			Assigned dose based on EDE2 Calculation									2018/01	9975489L						
00737	COLLAR			Pa	COLLAR			Assigned dose based on EDE2 Calculation									2018/01	9975490L						

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 (mSv)

Whole Body, Most Sensitive Organs, Adults	5,000
Lens of Eye	15,000
Extremities and Skin	50,000
Fetal (Pregnant female)	500
General Public	100

Based on the 10 NRC Regulations, Title 10, Part 20, Code of Federal Regulations and adopted by many states. Certain state and other regulatory agencies may address or otherwise limit.

Dosimeter Description: A dosimeter is included with each shipment of dosimeters for monitoring radiation exposure received during work. At the customer's facility, when the dosimeter is in a radiation-free area during the work period.

Minimal Dose Equivalent Reported: Dose measurements below the minimum measurable quantity for the current monitoring period are reported as "0". The normal reporting limits vary by the dosimeter type and radiation quality. "0" can also mean "upset" for the internal dose equivalent report when exposures less than 10 mrem report as "0". Includes total dose equivalent, and/or exposures of more than 10 mrem begin reporting at 10 mrem and report in increments of 10 mrem.

Dosimeter Type	M (Dose Equivalent)	M (Dose Only)	SL
Loop	1	-	10
Ring	5	-	10
Whole Body	-	10	10
Li Ring	-	30	-
Neutron Monitor Feet	10	-	-
Neutron Monitor Throat/Ear	10	-	-
Skin Ring	-	10	10

Special Considerations: Dosimeter calibration can be applied by radiation workers who wear lead aprons.

ED1: - One dosimeter worn on the waist (not under lead apron) and one worn at the collar level outside lead apron. 1.0 (Mantle DDE) + 0.04 (Collar DDE) = Assigned Dose Equivalent.

ED2: - One dosimeter worn at the collar level outside lead apron. 0.3 (Collar DDE) = Assigned Dose Equivalent.

ED3: - One dosimeter worn at the collar level outside lead apron. Collar DDE = Assigned Dose Equivalent.

ED4: - Lens of Eye Dosimeter. 0.3 Lens of Eye DDE = Assigned Lens of Eye Dose Equivalent.

ED5: - Lens of Eye Dosimeter. 0.175 Lens of Eye DDE = Assigned Lens of Eye Dose Equivalent.

ED6: - ATC DDE without Thyroid Collar assigned dose equivalent = 0.04 + collar dose + waist dose + wrist dose

ED7: - TC DDE with Thyroid Collar assigned dose equivalent = 0.04 + collar dose + wrist dose + waist dose

The "ASSIGNED" dose values are the original whole body dosimeter doses with the ED1 or ED2 calculation results in LANDAUER's standard Dose Assessment Protocol group and studies whole body dose from the highest reading whole body dosimeter, less than from dosimeter located to the eye).

Ring Dosimeter Readings: Ring dosimeter readings report at a shallow dose.

Fetal Dosimeter: A dosimeter program marker will assume a fetal exposure on all data pages of the report. Contact your local body dosimeter agent to obtain the fetal dose. The fetal dose is reported for the current work period. (See the attached sheet from conception to delivery if provided by customer), and the total dose from conception to present.

Use	Description	Use	Description
AREA	Area Monitor	CESTRM	Chest Extremity
CHGRT	Chest	DWGRDY	Other Whole Body
CTRL	Control	RNGLSL	Right Arm
COLLAR	Collar	RFGRD	Right Hand/Thng
EYE	Eye	RLGRM	Right Upper Arm
FETAL	Fetal	RLGRD	Right Upper Leg
LEADSL	Lead Shield	RWRGRT	Right Wrist
LFRMGR	Left Hand Ring	RPCGRM	Special Purpose
LFRMGR	Left Upper Arm	LFGRMGR	Upper Back
LGRD	Left Upper Leg	WRBT	Wrist
LWRMGR	Lower Back	WRGRDY	Whole Body
LWRMGR	Left Wrist		

Code	Radiation Quality Description (Type and Energy)
B	beta
BE	beta high energy, e.g. Thorium, Protactinium
BL	beta low energy e.g. Thallium, Tritium
BS	bremsstrahlung
BT	Thallium beta
BU	Uranium beta
BF	beta, neutron mixture
NU	neutron fast
NV	neutron thermal
P	photon (x or gamma ray)
PB	photon, beta mixture
PBN	photon, beta, neutron mixture
PH	photon high energy greater than 200 keV
PL	photon low energy less than 40 keV
PH	photon medium energy 40 keV to 200 keV
PN	photon, neutron mixture

First 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	Fast	Thermal	Other
Full-Body	00000	Yes	Yes	Yes	Yes	Yes
Collar	00001	Yes	Yes	Yes	Yes	Yes
Collar	00002	Yes	Yes	Yes	Yes	Yes
Collar	00003	Yes	Yes	Yes	Yes	Yes
Collar	00004	Yes	Yes	Yes	Yes	Yes
Collar	00005	Yes	Yes	Yes	Yes	Yes
Collar	00006	Yes	Yes	Yes	Yes	Yes
Collar	00007	Yes	Yes	Yes	Yes	Yes
Collar	00008	Yes	Yes	Yes	Yes	Yes
Collar	00009	Yes	Yes	Yes	Yes	Yes
Collar	00010	Yes	Yes	Yes	Yes	Yes
Collar	00011	Yes	Yes	Yes	Yes	Yes
Collar	00012	Yes	Yes	Yes	Yes	Yes
Collar	00013	Yes	Yes	Yes	Yes	Yes
Collar	00014	Yes	Yes	Yes	Yes	Yes
Collar	00015	Yes	Yes	Yes	Yes	Yes
Collar	00016	Yes	Yes	Yes	Yes	Yes
Collar	00017	Yes	Yes	Yes	Yes	Yes
Collar	00018	Yes	Yes	Yes	Yes	Yes
Collar	00019	Yes	Yes	Yes	Yes	Yes
Collar	00020	Yes	Yes	Yes	Yes	Yes
Collar	00021	Yes	Yes	Yes	Yes	Yes
Collar	00022	Yes	Yes	Yes	Yes	Yes
Collar	00023	Yes	Yes	Yes	Yes	Yes
Collar	00024	Yes	Yes	Yes	Yes	Yes
Collar	00025	Yes	Yes	Yes	Yes	Yes
Collar	00026	Yes	Yes	Yes	Yes	Yes
Collar	00027	Yes	Yes	Yes	Yes	Yes
Collar	00028	Yes	Yes	Yes	Yes	Yes
Collar	00029	Yes	Yes	Yes	Yes	Yes
Collar	00030	Yes	Yes	Yes	Yes	Yes
Collar	00031	Yes	Yes	Yes	Yes	Yes
Collar	00032	Yes	Yes	Yes	Yes	Yes
Collar	00033	Yes	Yes	Yes	Yes	Yes
Collar	00034	Yes	Yes	Yes	Yes	Yes
Collar	00035	Yes	Yes	Yes	Yes	Yes
Collar	00036	Yes	Yes	Yes	Yes	Yes
Collar	00037	Yes	Yes	Yes	Yes	Yes
Collar	00038	Yes	Yes	Yes	Yes	Yes
Collar	00039	Yes	Yes	Yes	Yes	Yes
Collar	00040	Yes	Yes	Yes	Yes	Yes
Collar	00041	Yes	Yes	Yes	Yes	Yes
Collar	00042	Yes	Yes	Yes	Yes	Yes
Collar	00043	Yes	Yes	Yes	Yes	Yes
Collar	00044	Yes	Yes	Yes	Yes	Yes
Collar	00045	Yes	Yes	Yes	Yes	Yes
Collar	00046	Yes	Yes	Yes	Yes	Yes
Collar	00047	Yes	Yes	Yes	Yes	Yes
Collar	00048	Yes	Yes	Yes	Yes	Yes
Collar	00049	Yes	Yes	Yes	Yes	Yes
Collar	00050	Yes	Yes	Yes	Yes	Yes
Collar	00051	Yes	Yes	Yes	Yes	Yes
Collar	00052	Yes	Yes	Yes	Yes	Yes
Collar	00053	Yes	Yes	Yes	Yes	Yes
Collar	00054	Yes	Yes	Yes	Yes	Yes
Collar	00055	Yes	Yes	Yes	Yes	Yes
Collar	00056	Yes	Yes	Yes	Yes	Yes
Collar	00057	Yes	Yes	Yes	Yes	Yes
Collar	00058	Yes	Yes	Yes	Yes	Yes
Collar	00059	Yes	Yes	Yes	Yes	Yes
Collar	00060	Yes	Yes	Yes	Yes	Yes
Collar	00061	Yes	Yes	Yes	Yes	Yes
Collar	00062	Yes	Yes	Yes	Yes	Yes
Collar	00063	Yes	Yes	Yes	Yes	Yes
Collar	00064	Yes	Yes	Yes	Yes	Yes
Collar	00065	Yes	Yes	Yes	Yes	Yes
Collar	00066	Yes	Yes	Yes	Yes	Yes
Collar	00067	Yes	Yes	Yes	Yes	Yes
Collar	00068	Yes	Yes	Yes	Yes	Yes
Collar	00069	Yes	Yes	Yes	Yes	Yes
Collar	00070	Yes	Yes	Yes	Yes	Yes
Collar	00071	Yes	Yes	Yes	Yes	Yes
Collar	00072	Yes	Yes	Yes	Yes	Yes
Collar	00073	Yes	Yes	Yes	Yes	Yes
Collar	00074	Yes	Yes	Yes	Yes	Yes
Collar	00075	Yes	Yes	Yes	Yes	Yes
Collar	00076	Yes	Yes	Yes	Yes	Yes
Collar	00077	Yes	Yes	Yes	Yes	Yes
Collar	00078	Yes	Yes	Yes	Yes	Yes
Collar	00079	Yes	Yes	Yes	Yes	Yes
Collar	00080	Yes	Yes	Yes	Yes	Yes
Collar	00081	Yes	Yes	Yes	Yes	Yes
Collar	00082	Yes	Yes	Yes	Yes	Yes
Collar	00083	Yes	Yes	Yes	Yes	Yes
Collar	00084	Yes	Yes	Yes	Yes	Yes
Collar	00085	Yes	Yes	Yes	Yes	Yes
Collar	00086	Yes	Yes	Yes	Yes	Yes
Collar	00087	Yes	Yes	Yes	Yes	Yes
Collar	00088	Yes	Yes	Yes	Yes	Yes
Collar	00089	Yes	Yes	Yes	Yes	Yes
Collar	00090	Yes	Yes	Yes	Yes	Yes
Collar	00091	Yes	Yes	Yes	Yes	Yes
Collar	00092	Yes	Yes	Yes	Yes	Yes
Collar	00093	Yes	Yes	Yes	Yes	Yes
Collar	00094	Yes	Yes	Yes	Yes	Yes
Collar	00095	Yes	Yes	Yes	Yes	Yes
Collar	00096	Yes	Yes	Yes	Yes	Yes
Collar	00097	Yes	Yes	Yes	Yes	Yes
Collar	00098	Yes	Yes	Yes	Yes	Yes
Collar	00099	Yes	Yes	Yes	Yes	Yes
Collar	00100	Yes	Yes	Yes	Yes	Yes

Dose, Eye and Shallow Dose Equivalents: Deep dose equivalent (DDE) applies to external whole body exposure at a dose depth of 1 cm (3000 mg/cm²). Eye dose equivalent (EDE) applies to external exposure of the lens at a dose depth of 0.3 cm (300 mg/cm²). Shallow dose equivalent (SDE) applies to the external exposure of the skin or extremity at a dose depth of 0.007 cm (7 mg/cm²) averaged over an area 1 cm².

Dose, Eye and Shallow Dose Equivalents: Report for the time frame indicated by the Monitoring Period. These doses represent the dose received only to the measurement specified. Individual calculation component results and combined totals report in separate files.

Quarterly accumulated results: reflect total dose received within a quarterly 3-month time frame and the customer defined start day. Quarterly accumulated values are determined for quarterly service or display. Total applicable 3-year or date equivalent total dose received from the beginning of the current year to report date. Lifetime accumulated total dose received from inception date of dosimeter service to report date, and total include earlier dose history if available to customer. Reported quarterly annual and lifetime dose accumulations represent the dose history from all measurement/accumulation instruments to be reported at the customer's end.

Receipt Date: The date LANDAUER began keeping dosimeter records for a given customer for a badge purchased on the current customer.

Serial Number: Dosimeter part number.

Second 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.

Notes: Total measured exposure may differ slightly as compared to the badge with the nearest activity of 1 mSv or less from the badge exposure information.

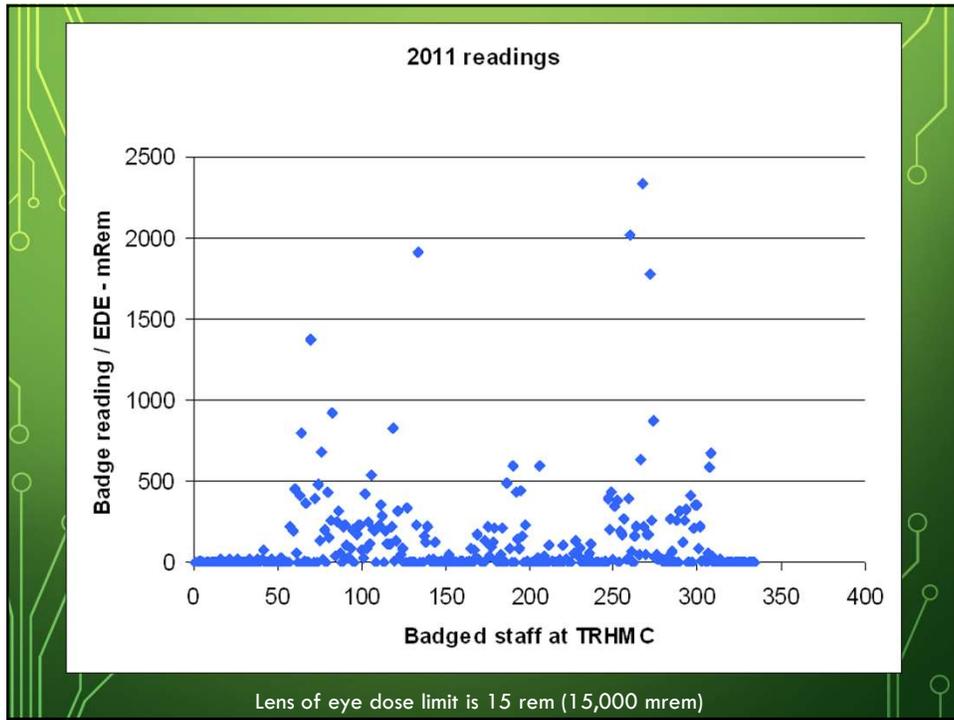
SL, Patient:
SL1, SL2, SL3, SL4, SL5, SL6, SL7, SL8, SL9, SL10

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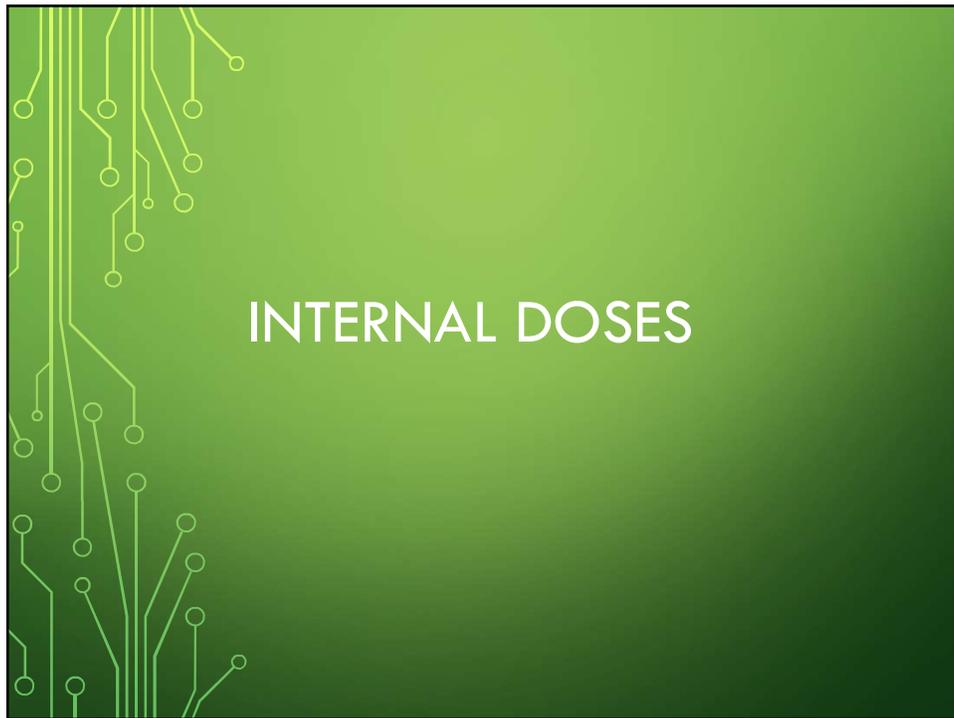
How to Read Your Dosimetry Report from LANDAUER - YouTube

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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

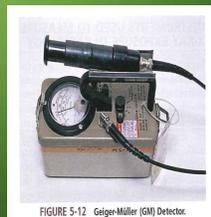


FIGURE 5-12 Geiger-Müller (GM) Detector.

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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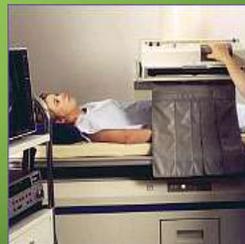
EQUIPMENT SURVEYS

- 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



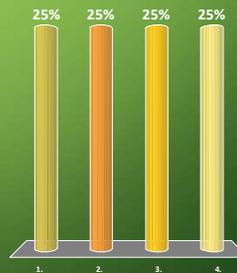
48

REVIEW QUESTIONS

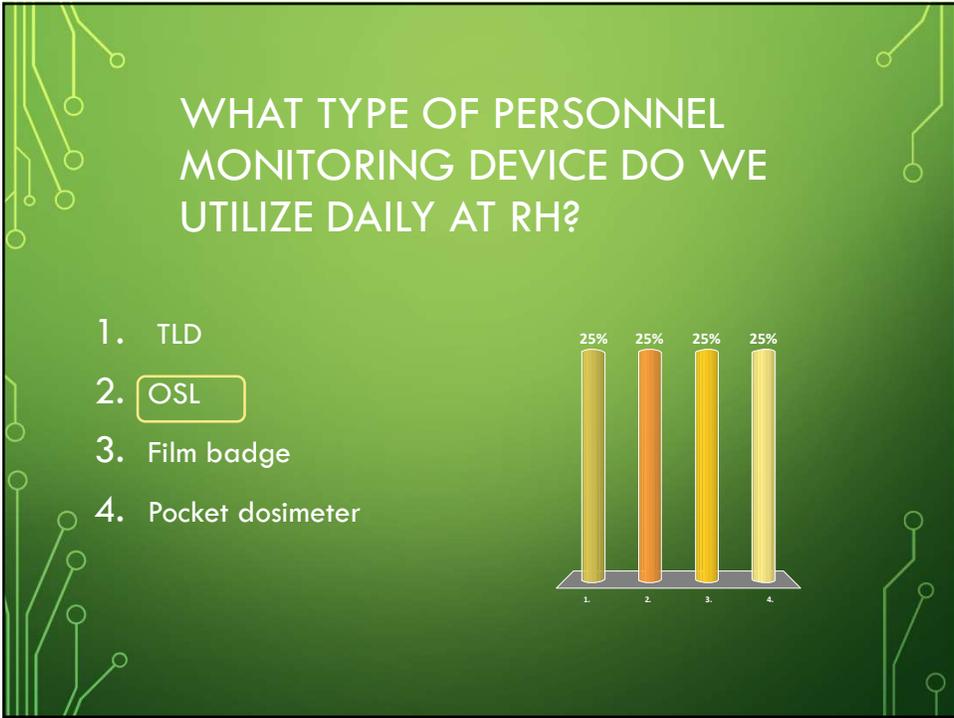
49

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

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



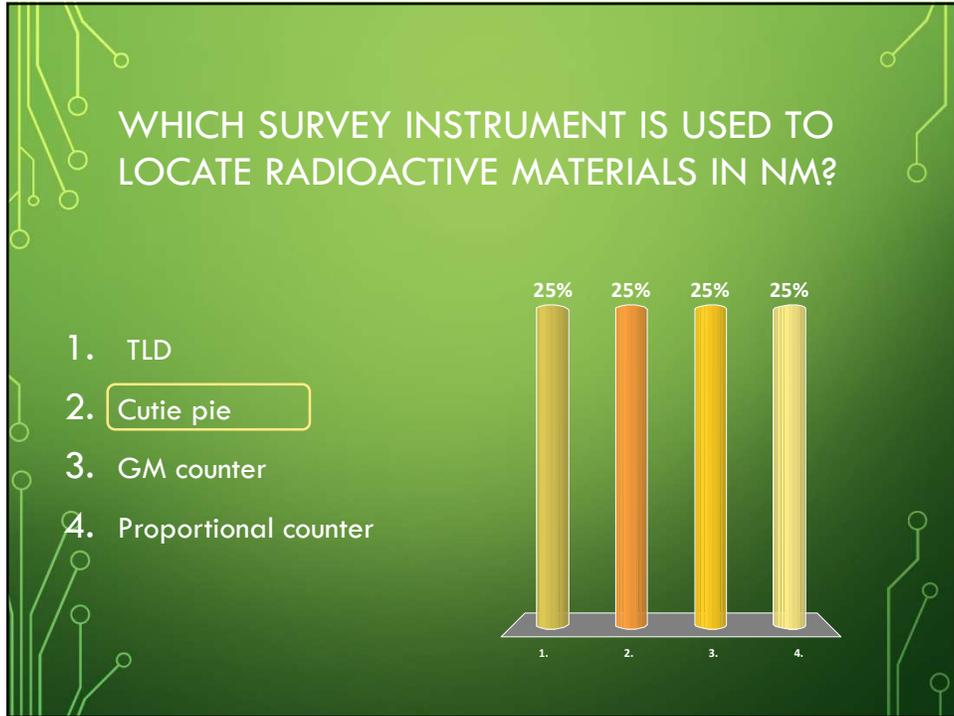
50



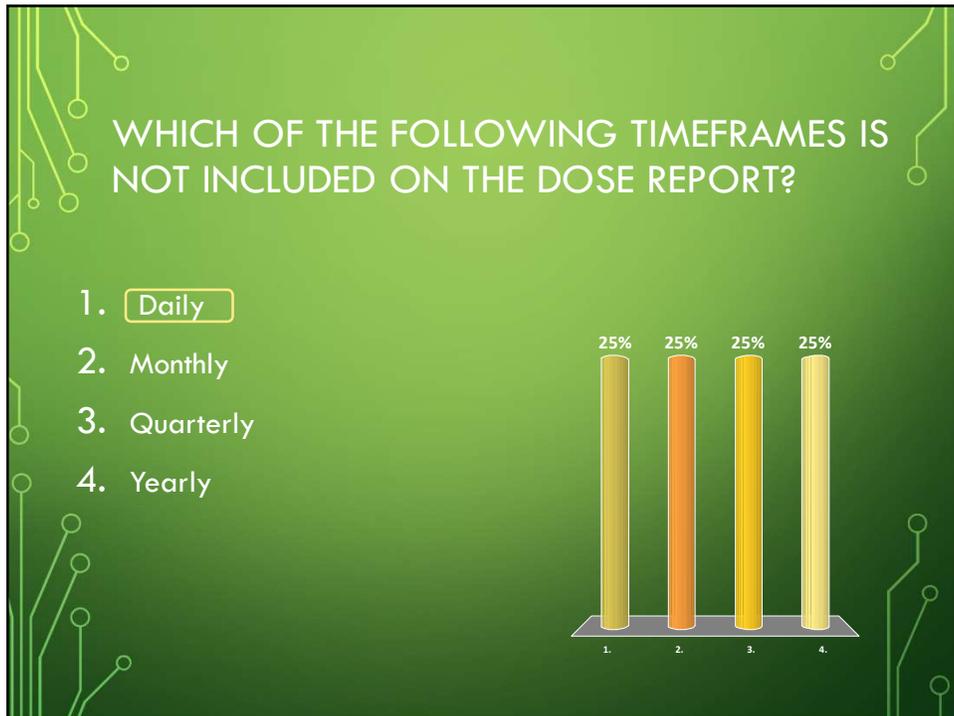
51



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WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

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WHAT IS THE SENSING MATERIAL IN A TLD?

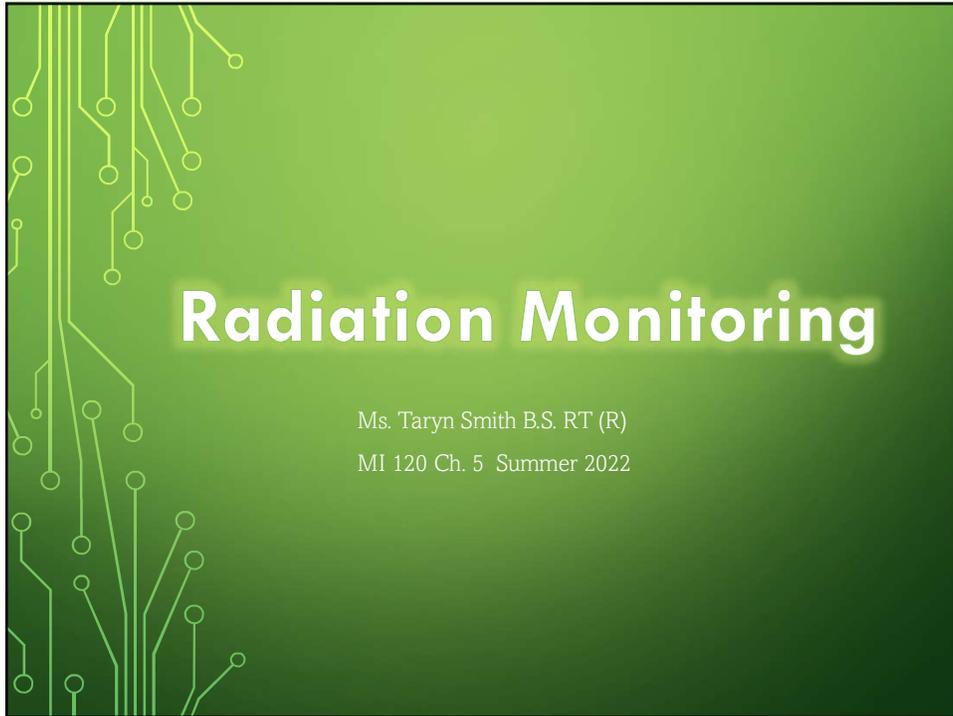
1. Barium sulfate
2. Calcium tungstate
3. **Lithium fluoride**
4. Sodium iodide

Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

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Radiation Monitoring

Ms. Taryn Smith B.S. RT (R)
MI 120 Ch. 5 Summer 2022

1

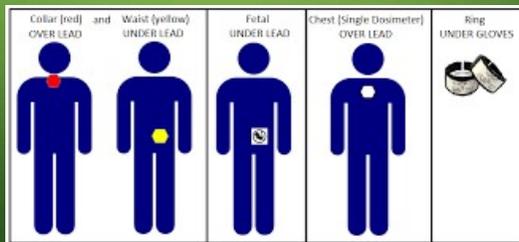


- Monitoring is used to ensure occupational radiation exposure levels are kept well below the EfD limit (annual effective dose)
- Technologist should be aware of the various radiation exposure monitoring devices and their functions

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



8

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 0.1 mGy
 - 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 to be sent out to be read



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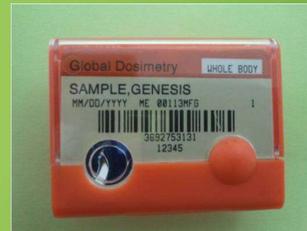
TLD- THERMOLUMINESCENT DOSIMETER

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



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TLD ADVANTAGES



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

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TLD DISADVANTAGES

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



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



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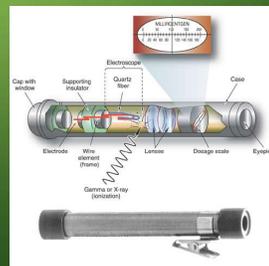
OSL DISADVANTAGES

- 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

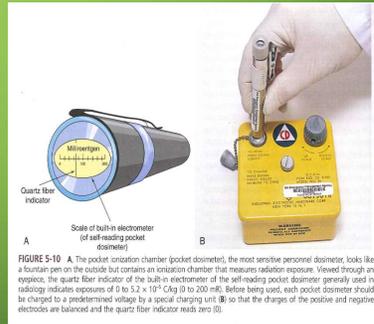
- Also known as a pocket dosimeter
- Most sensitive
- Uncommon to use in diagnostic radiology
- Resembles a fountain pen
- Contains 2 electrodes, one positive, one negative charged
- There is a:
 - self reading (contains an electrometer to provide reading)
 - non-self reading type (requires an accessory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



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POCKET IONIZATION CHAMBER ADVANTAGES

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



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

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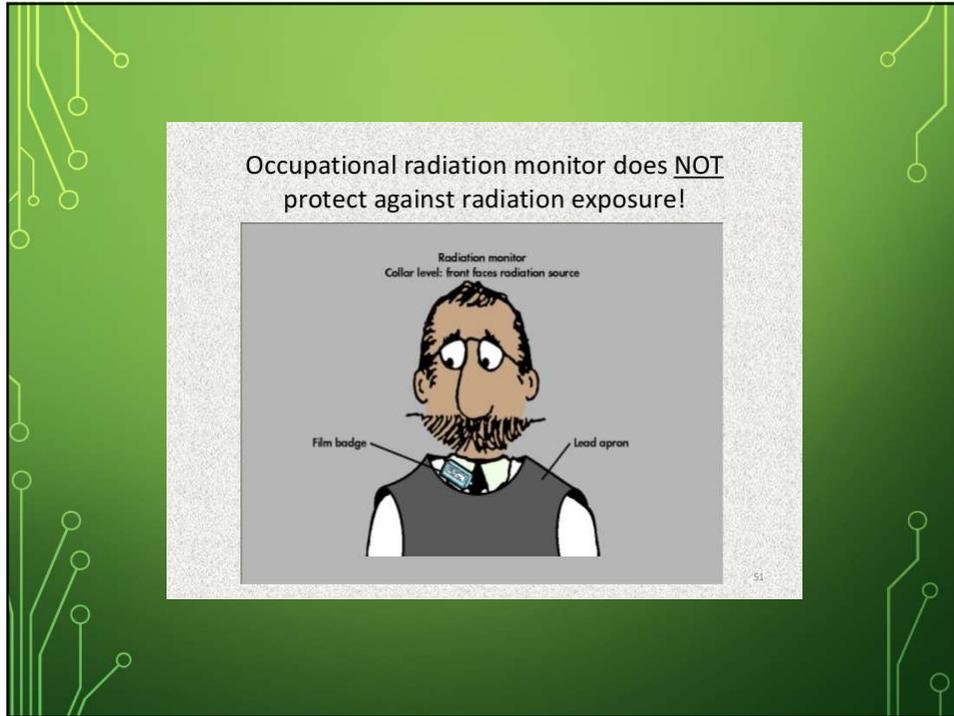
DIRECT ION STORAGE DOSIMETER DISADVANTAGES

- Not effective if not worn properly

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	Badge Type #1 Instadose®2	Badge Type #2 Instadose®3	Badge Type #3 Instadose®4	Badge Type #4 APex™	Badge Type #5 (LUMC) & R-230/231P or 231R	Badge Type #6 Genesis Ultra TLD™	Badge Type #7 Measuring™	Badge Type #8 Ultra™ & Flex™	
Personal Dosimeters									
Overview	All the advantages reported of traditional, non-etch measurement for film badge systems.	Instantaneous wireless reporting enables immediate action/feedback for film badge systems.	The only etched CRD compatible dosimeter available for personal direct ion measurements.	After dosimeter can be read multiple times, enabling an evaluation into several exposures.	Genesis Ultra TLD dosimeters, Genesis Ultra TLD-Blue are read using a standard RSO readout system, requires no special equipment.	Easy and frequent dosimeter use ideal for low or high energy beta, X-ray or gamma radiation monitoring of hands and fingers.			
Features	<ul style="list-style-type: none"> • Durable and easy replacement of dose reader on mobile smart devices, Instadose®2, Instadose®3 or Instadose®4. • 90% reduced background noise process. • Hands-free wireless reporting. • Identical, on demand dose work. • Recharge, replace and upgrade dose work. 	<ul style="list-style-type: none"> • Bluetooth wireless transmission of dose work on mobile smart devices, Instadose®2, Instadose®3 or Instadose®4. • 90% reduced background noise process. • Hands-free wireless reporting. • Identical, on demand dose work. • Recharge, replace and upgrade dose work. 	<ul style="list-style-type: none"> • Etched dose work. • Dose work badge collection and calibration process. • Immediate online reporting. • Improved compliance. 	<ul style="list-style-type: none"> • Rechargeable battery for use in vehicle and tracking. • Works both, dose monitoring. • Rechargeable. • Flexible display panel: accurate reading even when exposed to various temperatures or moisture. 	<ul style="list-style-type: none"> • New generation of TLDs in form of discs and wafers for identification and tracking. • Multiple body units, easy monitoring. • Thermal stability and excellent moisture resistance. • Long lifetime, low level of eye dose. 	<ul style="list-style-type: none"> • Individually calibrated. • Available in 4 sizes. • Can be immersed in water and used underwater using ClearShield™ CR-39 or CR-39 MicroShield™ (0.2 - 2.0 mm and 0.75 mm) used by 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000. 	<ul style="list-style-type: none"> • Strong hand/glove construction. • Available in 3 sizes. • Flex Ring. • Full plastic construction with index (three sizes). • 0.25 mm and 0.75 mm used by 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000. 		
Applications	Requires potentially exposed to occupational radiation. Can also be used for area monitoring.	Requires potentially exposed to occupational radiation. Can also be used for area monitoring.	Requires potentially exposed to occupational radiation. Can also be used for area monitoring.	Requires potentially exposed to occupational radiation. Can also be used for area monitoring.	Requires potentially exposed to occupational radiation. Can also be used for area monitoring.	Individual handling, subdosimetry, performance enhancement, radiographic protection, or other high risk of radiation exposure to hand, hands and fingers.			
Description	Instadose®2 (Instadose®2) and Instadose®3 (Instadose®3) use the same CRD technology (MicroShield™) as Instadose®4.	Instadose®3 (Instadose®3) uses the same CRD technology (MicroShield™) as Instadose®2.	Instadose®4 (Instadose®4) uses the same CRD technology (MicroShield™) as Instadose®2 and Instadose®3.	Instadose®4 (Instadose®4) uses the same CRD technology (MicroShield™) as Instadose®2 and Instadose®3.	Genesis Ultra TLD (Genesis Ultra TLD) uses the same CRD technology (MicroShield™) as Instadose®2, Instadose®3 and Instadose®4.	Genesis Ultra TLD (Genesis Ultra TLD) uses the same CRD technology (MicroShield™) as Instadose®2, Instadose®3 and Instadose®4.	Measuring™ (Measuring™) uses the same CRD technology (MicroShield™) as Instadose®2, Instadose®3 and Instadose®4.	Ultra™ & Flex™ (Ultra™ & Flex™) uses the same CRD technology (MicroShield™) as Instadose®2, Instadose®3 and Instadose®4.	
Min. Reportable Dose (MRD) & Useful Dose Range	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	0.05 mSv - 100 mSv 0.05 mSv - 100 mSv	
Energy Response	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	Photo: 1 mSv - 0.05 mSv Beta: 0.05 mSv - 100 mSv	
Accreditations	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	US: NIST (see code 100000-0) NIST other countries	
Holder Type Prog. size and requirements for exposure	AWARD WINNING PATENT Most Innovative On-Demand Dosimetry System			BP (Blue Body)	DA, DL, DR				

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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

LANDAUER
LANDAUER, Inc., 2 Science Road
Glenwood, Illinois 60425-1586
landauer.com
Telephone: (708) 755-7000
Facsimile: (708) 755-7016
Customer Service: (800) 323-8850
Technical: (800) 438-3241

Radiation Dosimetry Report

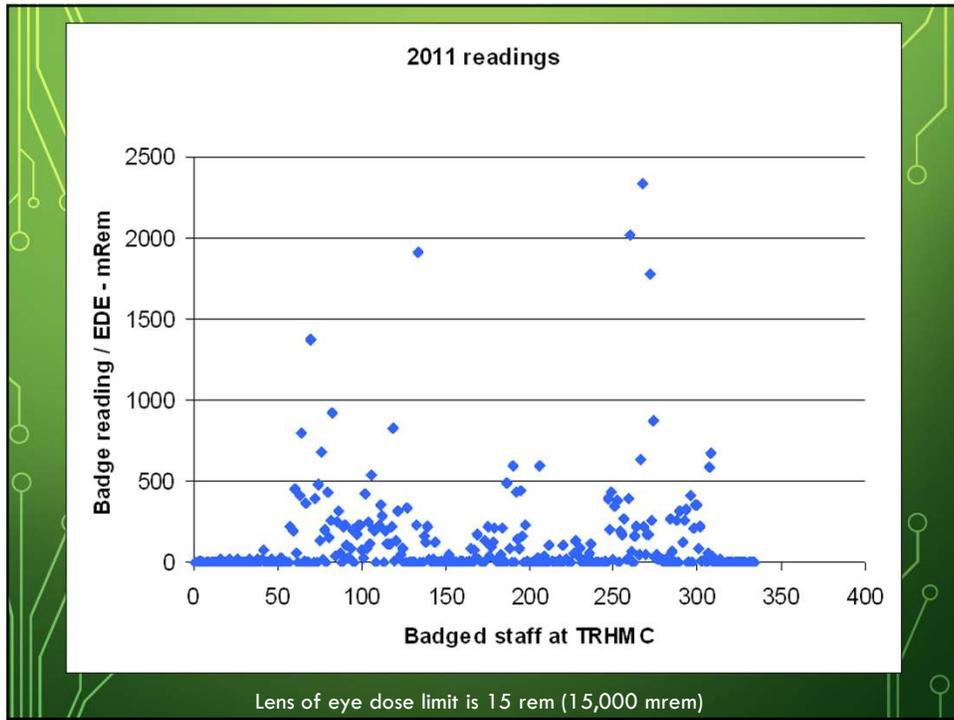
Account : 719 Account: 1456718 Series: SHS

*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.

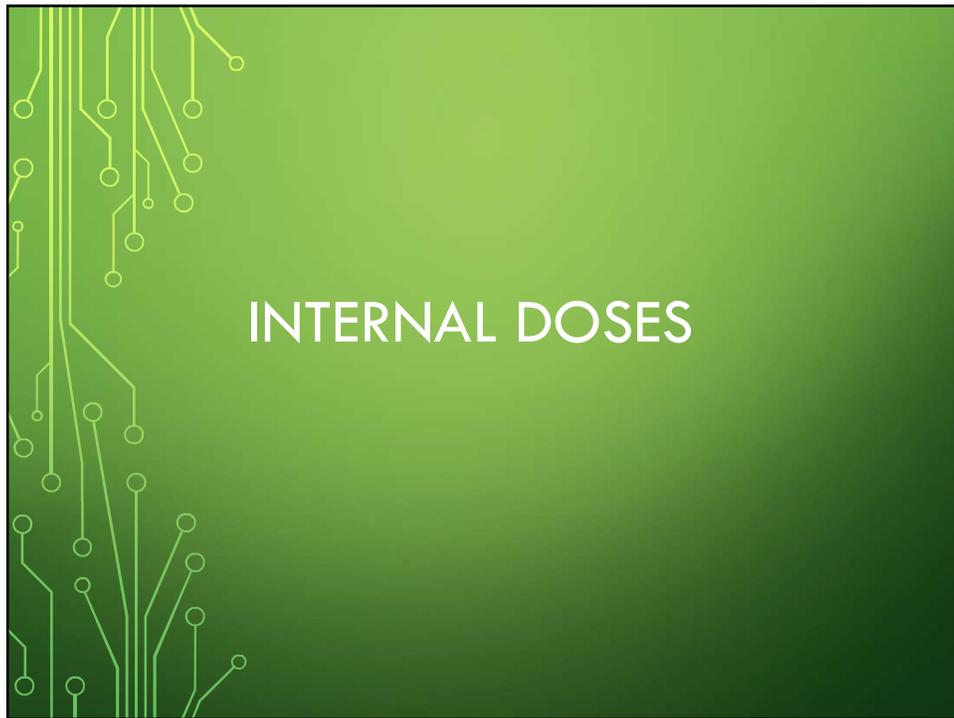
Participant Number	Name	ID Number	Birth Date	Dosimeter	Use	Risk Type	Risk Quality	Dose Equivalent (mrem) for Periods Shown Below									Inception Date	Serial Number						
								Period Shown Below			Quarter to Date			Year to Date					Lifetime to Date					
								DDE	LDE	SDE	DDE	LDE	SDE	DDE	LDE	SDE			DDE	LDE	SDE			
For Monitoring Period: 2022-03-01 to 2023-02-29								QUARTER 1			2022			LIFETIME										
00539	CONTROL			Pa	CONTROL			13	13	13	M	M	M	M	M	M	M	M	M	143	285	273	2018/01	9075484L
00641	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	138	157	156	2018/01	9075485L
00712	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	58	67	67	2018/01	9075486L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00714	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	806	806	806	2018/01	9075487L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00720	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	116	130	129	2018/01	9075488L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00725	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	119	119	119	2018/01	9075489L
	ASSIGNED NOTE							Assigned dose based on EDE2 Calculation																
00737	COLLAR			Pa	COLLAR			M	M	M	M	M	M	M	M	M	M	M	M	159	159	159	2018/01	9075490L
	ASSIGNED NOTE							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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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

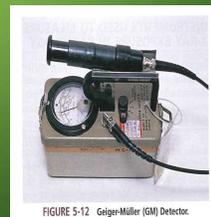


FIGURE 5-12 Geiger-Müller (GM) Detector.

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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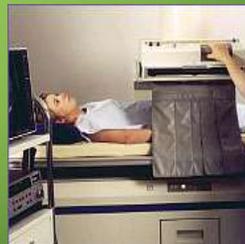
EQUIPMENT SURVEYS

- 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



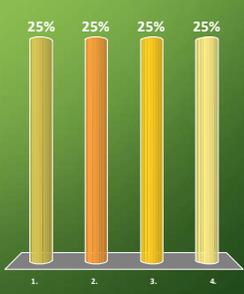
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REVIEW QUESTIONS

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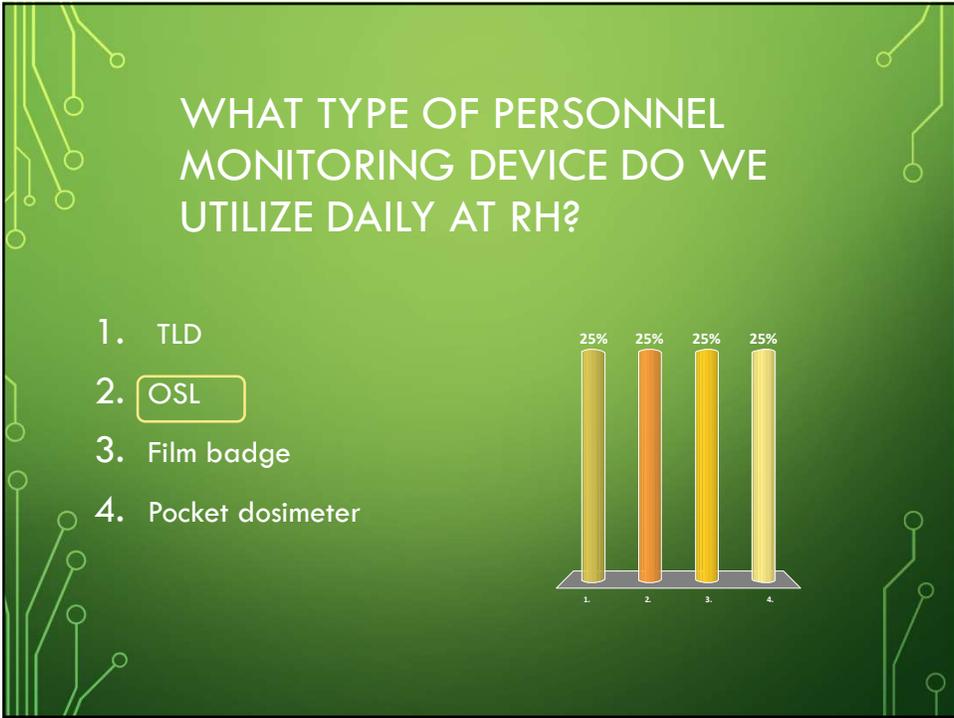
WHICH DOSE ON THE BADGE REPORT IS CONSIDERED THE ABSORBED DOSE?

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



Option	Percentage
1. Deep dose	25%
2. Shallow dose	25%
3. Eye dose	25%
4. Lens dose	25%

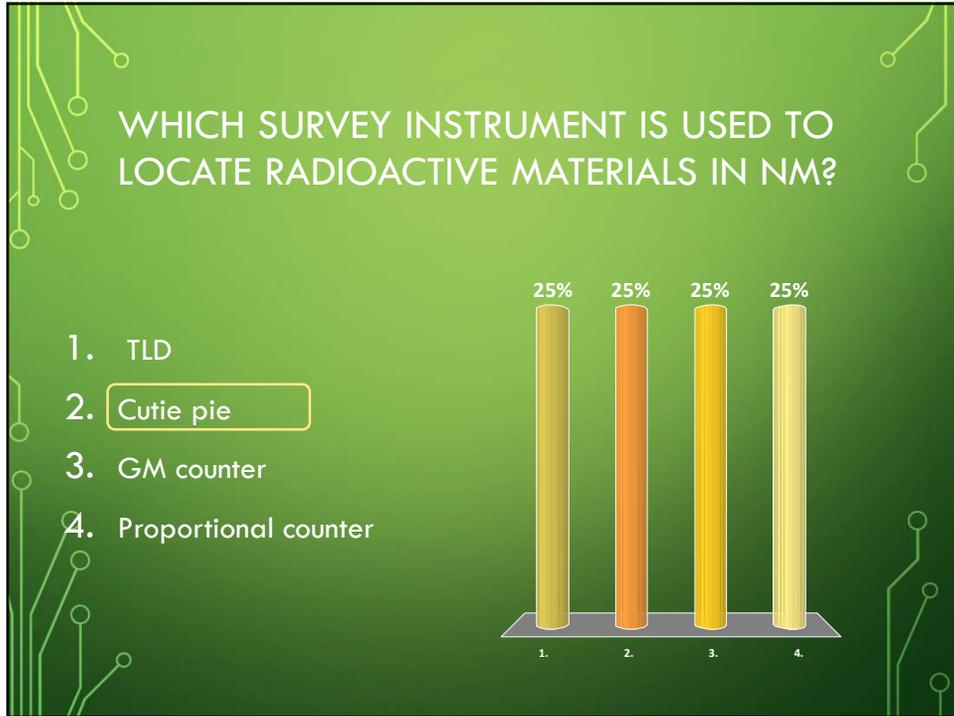
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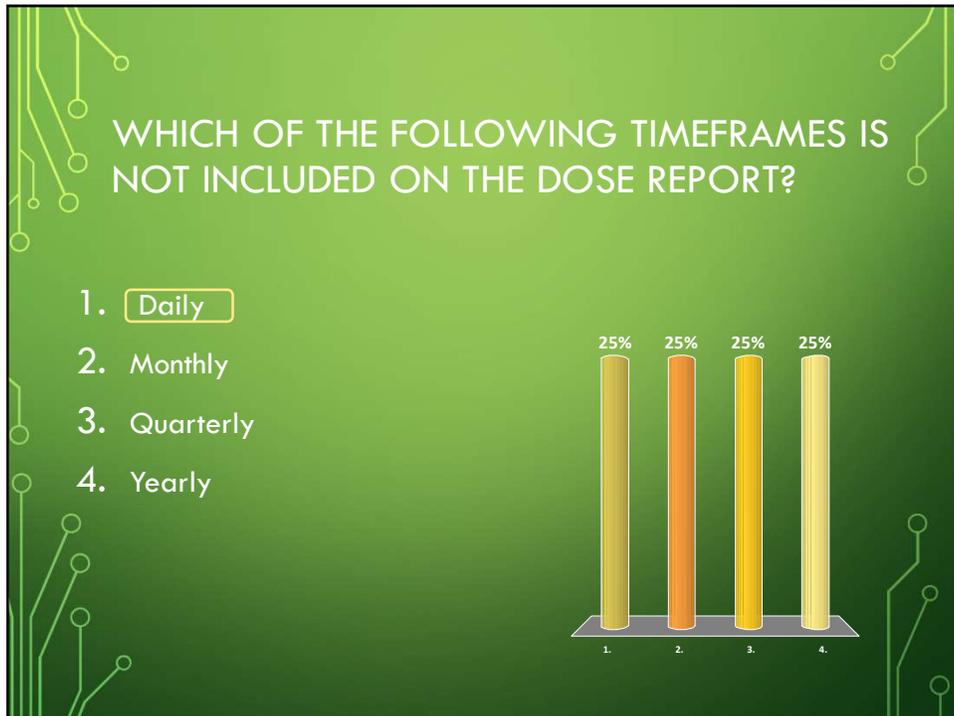
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WHICH PERSONNEL MONITORING DEVICE PROVIDES AN IMMEDIATE READOUT?

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

Device	Percentage
OSL	25%
TLD	25%
Film badge	25%
Pocket dosimeter	25%

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WHAT IS THE SENSING MATERIAL IN A TLD?

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

Sensing Material	Percentage
Barium sulfate	25%
Calcium tungstate	25%
Lithium fluoride	25%
Sodium iodide	25%

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