Debunking Myths and Urban Legends in Ionizing Radiation Dosimetry

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Embracing our purpose – Anticipating Radiation Measurement Needs

April 13, 2026

Myths and Urban Legends #1

"If I use a NVLAP Accredited dosimeter I'm in compliance with 10CFR20."

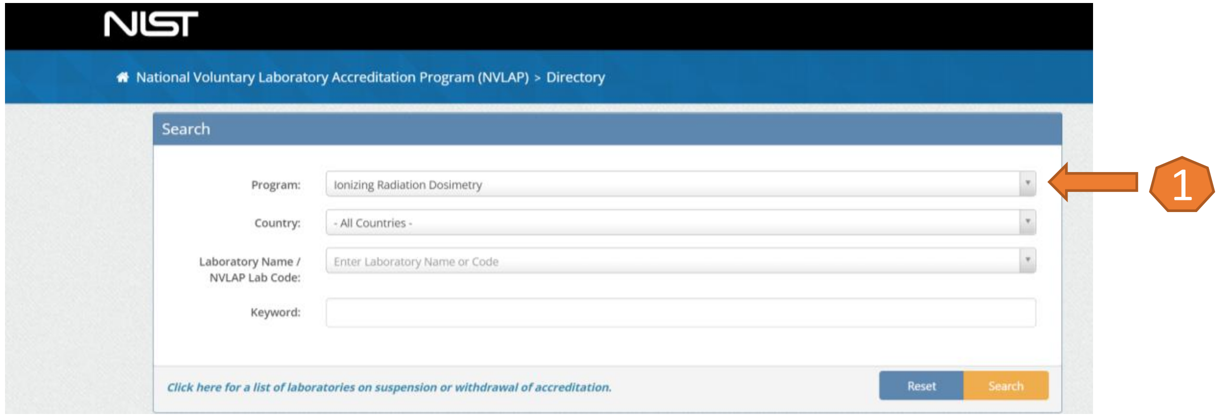
10CFR20.1501 General[1]

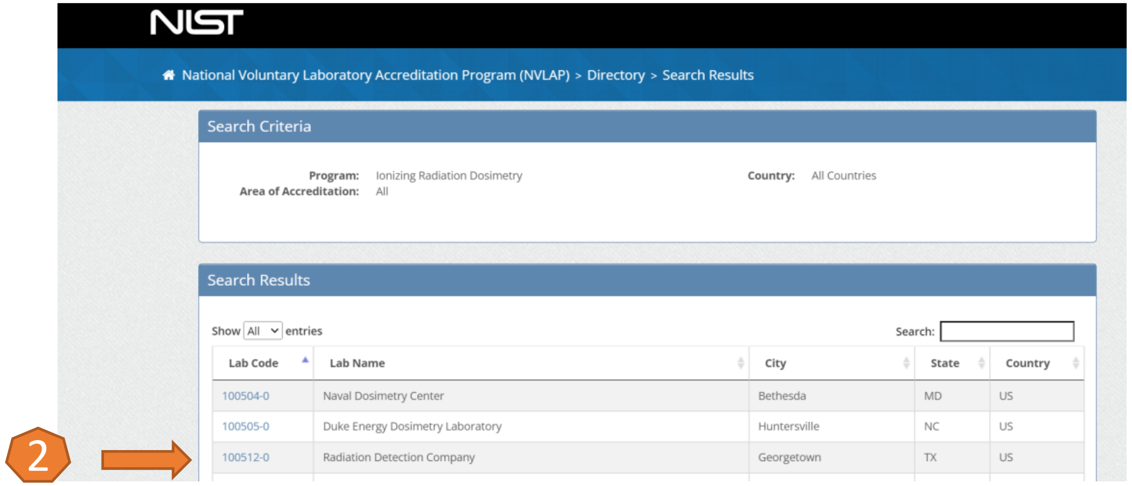
(d) All personnel dosimeters (except for direct and indirect reading pocket ionization chambers and those dosimeters used to measure the dose to the extremities) that require processing to determine the radiation dose and that are used by licensees to comply with § 20.1201, with other applicable provisions of this chapter, or with conditions specified in a license must be processed and evaluated by a dosimetry processor—

(1) Holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology; and

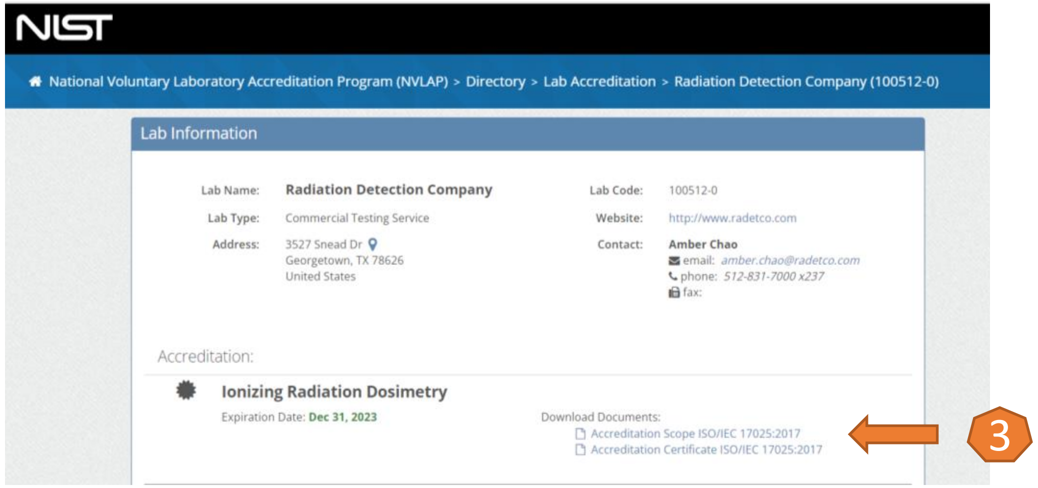
(2) Approved in this accreditation process for the type of radiation or radiations included in the NVLAP program that most closely approximates the type of radiation or radiations for which the individual wearing the dosimeter is monitored.

NVLAP Scope of Accreditation Listing on NIST Website





- NVLAP Scope of Accreditation for Ionizing Radiation Dosimetry
  - http://www-s.nist.gov/niws/index.cfm?event=directory.search#no-back
  - Select Ionizing Radiation Dosimetry Form Drop down and click Search
- List of Accredited Labs
  - Click Lab Codes
- Lab Information
  - Click on Scope to determine what dosimeter models have passed performance testing and the specific ANSI N13.11 categories accredited.



NVLAP Scope of Accreditation for Laboratory

- Specific ANSI N13.11 categories the dosimeter model is NVLAP accredited.[2]
  - I - Accident Photons
  - II – Photons/Photon Mixtures
  - III – Betas
  - IV - Mixtures of Photons + Betas
  - V- Mixtures of Neutrons + Photons
- What does A, B, C, and D mean?
  - NVLAP Accreditation is not a blanket approval. If dosimeters are not tested in the category, they are not accredited for the radiation field.
  - If the dosimetry processor select only category A, General, the dosimeter does not require a priori knowledge of the radiation environment to accurately assess the dose.
  - If a dosimetry provider selects specific photon or beta performance testing subcategories B, C, or D then they are only accredited for that energy range.

NOTE: Subcategory B, C, or D on NVLAP Scope the dosimeter has limitations for that radiation field.

National Voluntary
Laboratory Accreditation Program

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

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IONIZING RADIATION DOSIMETRY **NVLAP LAB CODE 100512-0**

Scope of Accreditation:

This facility has been evaluated and deemed competent to process the radiation dosimeters listed below through employing the following processing/reading equipment: (1) Panasonic UD 716 automatic TLD readers; (2) 6600 Harshaw TLD reader; (3) 8800 Harshaw TLD reader; (4) BeOSL Reader 2.0.

WHOLE BODY

This facility is accredited to process the following dosimeters by demonstration of compliance with ANSI HPS N13.11-2009 through testing.

Code 82 TLD model XBGN, process 1 for categories IA, IIA, IIIA, and IVAA.

Code 82H TLD XBGN, process 3 for categories IA, IIA, IIIA, IVAA and VCA.

Code 84 BeOSL XG, process 4 for categories IA and IIA.

EXTREMITY

This facility is accredited to process the following dosimeters by demonstration of compliance with ANSI HPS N13.32-2008 through testing.

Code 05 TLD XBG finger ring, process 2 for categories IA, IIA, IIIA, and IVAA.

Code 82WH TLD XBGN wrist badge, process 3 for categories IA, IIA, IIIA, and IVAA.

For the National Voluntary Laboratory Accreditation Program

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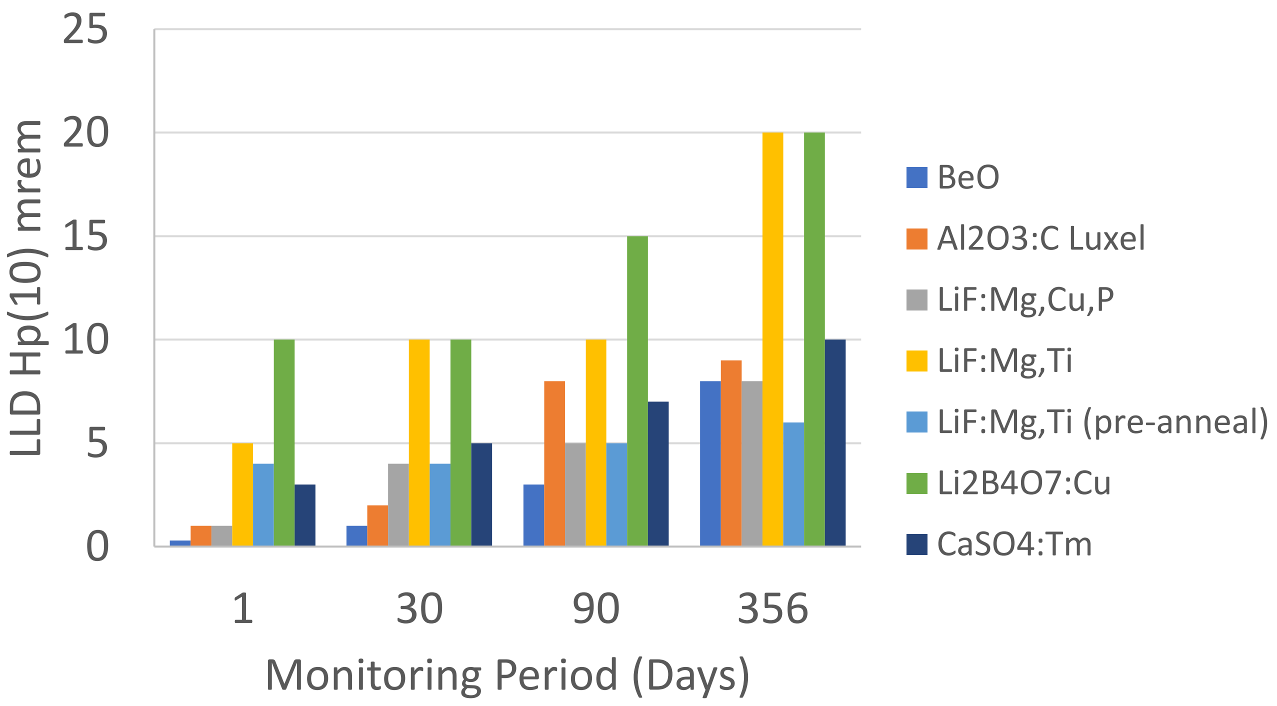
Myths and Urban Legends #2

"TLD's have a lower limit of detection (LLD) of 10 mrem (0.1 mSv) and OSL is 1 mrem (0.01 mSv)."

LLD Misconceptions

Comparison of LLD as a Function of Time for Various Dosimeter Technologies [3,4,5,6,7,8,9]



- Lower Limit of Detection (LLD) varies as a function of monitoring frequency.
  - LLD varies due to the standard deviation of the background dosimeters, Equation 1.
- Using an LLD of 1 mrem for all monitoring frequencies will lead to inaccurate reporting of dose.

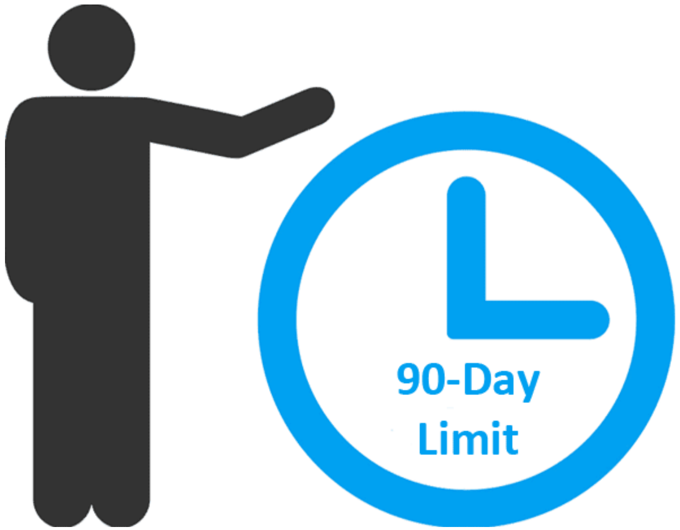
Equation 1. Lower Limit of Detection

$$LLD = \frac{2[t_p S_o + (t_p S_1/H_1)^2\ H'_o}{[\ 1 - (t_p S_1/H_1)^2\ ]}$$

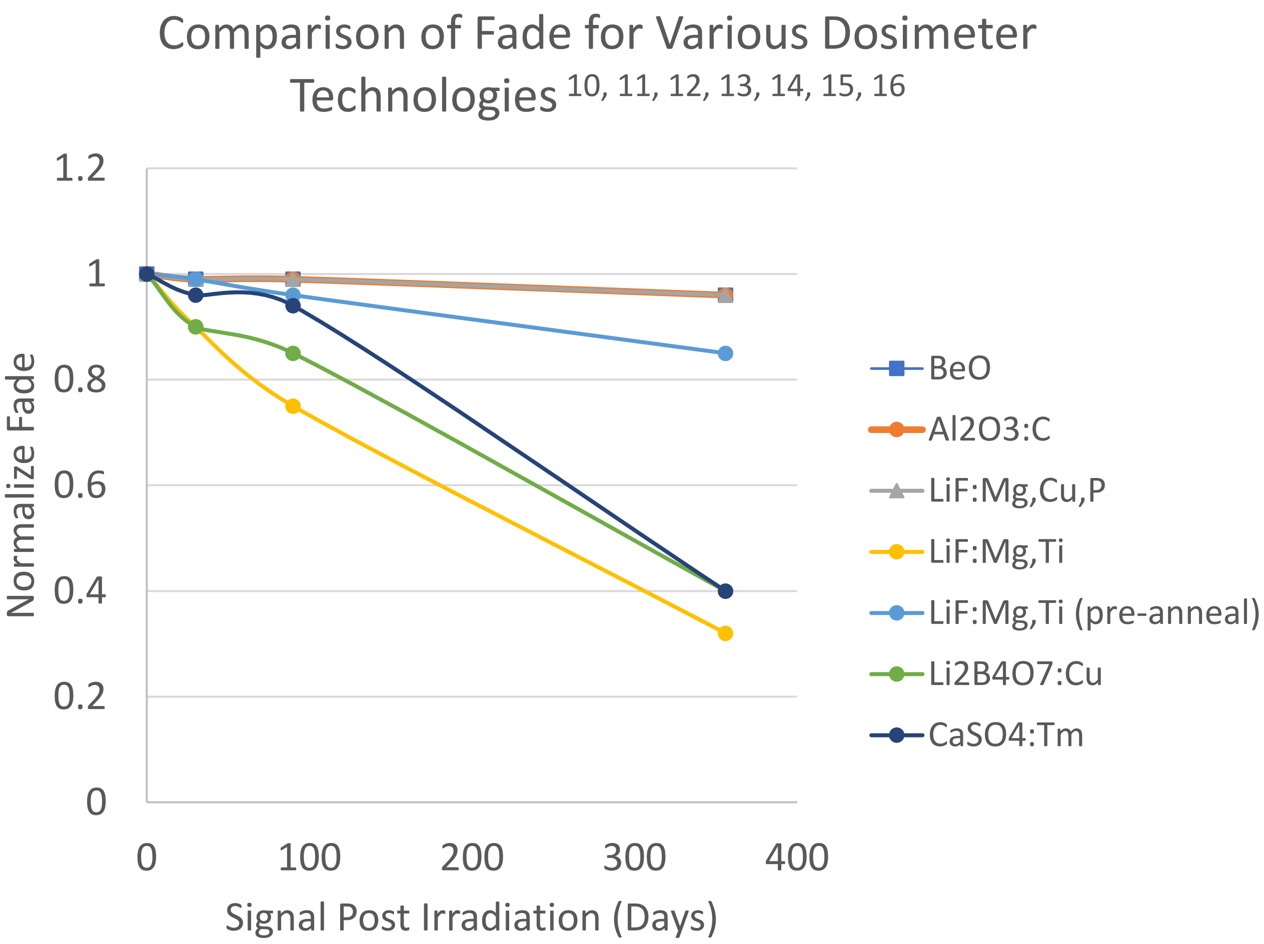
t_p = t distribution for n-1 degree of freedom and a p value of 0.95
S_o = standard deviation of the unirradiated dosimeter results
S_i = standard deviation of the irradiated dosimeter results
H_1 = average of the irradiated dosimeter results
H'_o = average of the unirradiated dosimeter results without subtracting background

Myths and Urban Legends #3

"Thermoluminescent dosimeters (TLD) can not be used for wear periods beyond a quarter due to fade."



Fade - Urban Legends



- Fade is the loss of signal induced in a detector over time post irradiation.
  - BeO, Al_2O_3:C, and LiF:Mg,Cu,P have similar fade of ~4% per year.
  - Even though LiF:Mg,Cu,P has been around since 1994 its fade is mistakenly assumed to be the same as LiF:Mg,Ti.
  - LiF:Mg,Ti TLD systems can be optimized to significantly improve fade using a pre-anneal process.

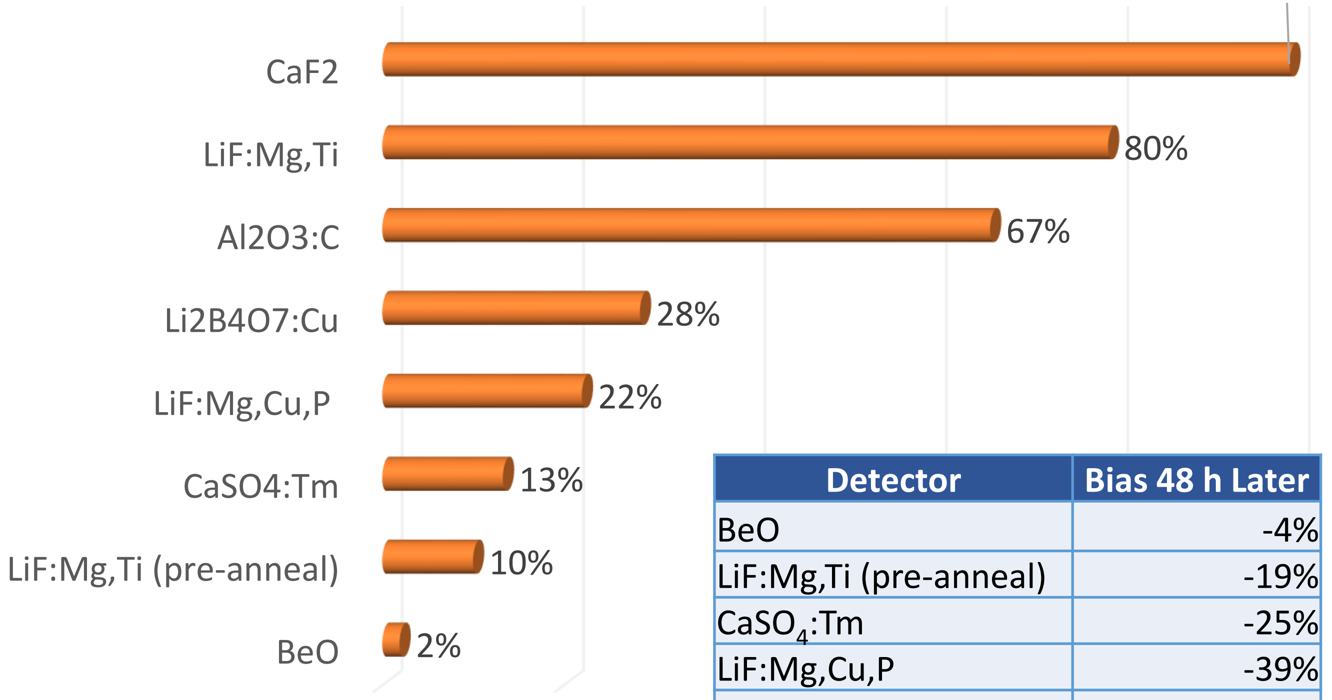
Myths and Urban Legends #4

"Leaving my dosimeter in a car will not impact the reading."

Heat Induced Effects on Dosimeter Materials

- Thermally fading can occur for all dosimeters that result in the release of trapped electrons.
- Dosimetry systems on the market using BeO, Al_2O_3:C, and LiF:Mg,Cu,P have passed the IEC 62387 temperature test.
  - Dosimeters response within -17% to +25% of the delivered dose after being subjected to 122ºF (50ºC) for a 1-week duration. [17]
- Extreme temperature testing has also been conducted, since car temperatures can reach temperatures as high as 160ºF (71ºC).[18]
- Testing conducted at 201ºF (94ºC) for 24 hours to simulate a worker storing the dosimeter in a car.
- Significant loss in signal for a dosimeter stored in a car over a weekend.

SIGNAL LOSS DOSIMETER IN AMBIENT TEMP 201ºF (94ºC) FOR 24H [18, 19, 20, 21, 22]



Detector	Bias 48 h Later
BeO	-4%
LiF:Mg,Ti (pre-anneal)	-19%
$CaSO_4$:Tm	-25%
LiF:Mg,Cu,P	-39%
$Li_2B_4O_7$:Cu	-49%
Al_2O_3:C	-89%
LiF:Mg,Ti	-96%
CaF_2	-100%

Myths and Urban Legends #4

"It's easy to pass the CHP Exam when you get the build a dosimeter question."

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Given the information in the following table, construct a dosimeter to measure the effective dose equivalent for each of the following workers specified in Parts D and E. Clearly state the number of the chips to be included in the dosimeter and limit the number of chips to a maximum of four. **Provide justification for your selections.**

Chip	Material	Thickness	Cover
1	^{7}LiF	0.38 cm	100 mg cm^{-2} copper and 200 mg cm^{-2} plastic
2	^{7}LiF	0.38 cm	1000 mg cm^{-2} plastic
3	^{7}LiF	0.15 cm	7 mg cm^{-2} mylar
4	^{6}LiF	0.38 cm	300 mg cm^{-2} plastic
5	^{7}LiF	0.38 cm	300 mg cm^{-2} plastic
6	^{6}LiF	0.38 cm	300 mg cm^{-2} plastic and Cd filter

All fun and games when the detector is tissue equivalent, and you must build the dosimeter for an X-ray technologist.

What if you were given non-tissue equivalent material?

Note: Effective Atomic Number (Z_{eff}) for soft tissue is ~7.2 and H_2O is ~7.4

Detector	Z_{eff}	Photon Response 40 - 60 keV (80 - 120 kVp)	Design & Algorithm
BeO:Na,Tb,Ga (Dosimetric OSL)	7.2	Over response 5-10%	• *Hp*(0.07) 7 mg/cm^2 mylar and *Hp*(10) 1000 mg/cm^2 plastic • Simple algorithm the reading is the dose.
$Li_2B_4O_7$:Cu (Panasonic TLD)	7.3	Over response 20-30%	• *Hp*(0.07) 7 mg/cm^2 mylar and *Hp*(10) 1000 mg/cm^2 plastic • Simple algorithm the reading is the dose.
LiF:Mg,Cu,P (Harshaw TLD)	8.2	Over response 20-30%	• *Hp*(0.07) 7 mg/cm^2 mylar and *Hp*(10) 1000 mg/cm^2 plastic • Simple algorithm the reading is the dose.
LiF:Mg,Ti (Harshaw TLD)	8.2	Over response 20-30%	• *Hp*(0.07) 7 mg/cm^2 mylar and *Hp*(10) 1000 mg/cm^2 plastic • Simple algorithm the reading is the dose.
Al_2O_3:C (Landauer OSL)	11.3	Over response by a factor of 3 to 4	• Can't use a simple design due to the over response. Will need more detectors and read locations to accurately assess *Hp*(0.07) and *Hp*(10). • Complex algorithm required to arrive and the correct dose. • Will need to characterize the photon energy to apply appropriate corrections.
$CaSO_4$:Tm (Panasonic TLD)	15.6	Over response by a factor of 10 to 12	• Can't use a simple design due to the over response. Will need more detectors and read locations to accurately assess *Hp*(0.07) and *Hp*(10). • Complex algorithm required to arrive and the correct dose. • Will need to characterize the photon energy to apply appropriate corrections.

Conclusion

- Many myths and legends surround dosimeter technology from lower limit of detection to ruggedness & durability that are easily debunked in scientific literature or testing.
- Did these myths come from the desire to paint the dosimetry technology that a laboratory may be using as the elusive ideal dosimeter?
- Regardless of the claims that may be made about a dosimetry technology it’s important to remember the following:
  1) Select a dosimeter that is NVLAP accredited in the radiation environments that you have at your site and pay close attention to any limitations it may have.
  2) Ask for the studies that back up performance claims because sometimes beliefs surrounding your chosen “dosimetric religion” may not be true or grounded in scientific data.
  3) Pray you don’t get the build a dosimeter question using non-tissue equivalent detectors on the CHP Part II exam.

From Assumptions to Actionable Needs

- The field faces gaps between measurement, interpretation, and action
- Emerging evidence and technologies are challenging legacy models
- There is a clear need to anticipate and redefine measurement priorities
- These gaps define the most important Needs we should be solving for as a community.

Need: Resolving Low-Dose Risk Uncertainty

Scientific or Technical Challenge

- Persistent uncertainty in low-dose risk (LNT vs non-LNT)
- Current system assumes LNT as default, despite ongoing scientific debate and EO14300 pressures
- Dosimetry measures dose precisely, but risk interpretation remains unresolved
- EO14300 could eliminate the collection of critical dosimetry data required to finalize scientific decision on LNT.

Potential Scientific or Technological Impact

- Enables evidence-based updates to regulatory frameworks and dose limits
- Reduces unnecessary operational burden driven by overly conservative assumptions
- Aligns radiation protection with real-world risk, not legacy models

Summary of research direction

- Advance and translate findings from the Million Person Study (MPS)
- Leverage momentum from Executive Order 14300 calling for re-evaluation of radiation risk models
- Expand industry efforts (including our work) to challenge assumptions and align measurement with observed outcomes

References

- NCRP Million Person Study (MPS):
- Executive Order 14300 (2025)

Need: Enable Safe Reduction of Shielding (Lead Aprons)

Scientific or Technical Challenge

- Movement toward removing lead aprons in fluoro environments
- No reliable way today to detect shielding gaps or scatter risk in real time
- Current monitoring is too delayed to catch problems
- Regulations not keeping pace.

Potential Scientific or Technological Impact

- Reduces orthopedic burden from lead
- Identifies bad positioning, shielding failures, workflow risks immediately
- Supports safe modernization of clinical practice

Summary of research direction

- Develop real-time, high-resolution dosimetry
- See where dose is happening (spatial) and when it's happening (temporal).
- Establish standards for low/no shielding environments
- Updating of Webster effective dose equivalent (EDE) calculations

References

- NCRP 168 (Fluoroscopy)
- IAEA Fluoroscopy Safety Guidance
- Dauer et al., Health Physics (2010)

References

1. U.S. Nuclear Regulatory Commission Regulations: Title 10, *Code of Federal Regulations, Part 20,* 10CFR20, *Standards for Protection Against Radiation*.
2. ANSI/HPS N13.11, *Personnel Dosimetry Performance - Criteria for Testing*, January 2009
3. C. Passmore, *BeOSL Background Rate and LLD as Function of Time Study 04042023*, Spreadsheet, Radiation Detection Company, April 2023
4. C. Hock, *Luxel+ Dosimeter Lower Limit of Detection*, 2012
5. J. Cassada, *A new paradigm in personal dosimetry using LiF:Mg,Cu,P*, Radiation Protection Dosimetry, 2022 101(1-4):27-42
6. L. Lou, *Long term study of Harshaw TLD LiF – LLD and uncertainty*, Radiation Measurements, Volume 45, Issues 3–6, 2010, Pages 569-572
7. PNNL-15750 Rev. 0.2 PNL-MA-842, *Hanford External Dosimetry Technical Basis Manual*, August 2009
8. C. Passmore, Lower Limit of Detection of Panasonic UD-802, Pantex Plant, 1994.
9. C. Passmore, Lower Limit of Detection of Panasonic UD-802, Pantex Plant, 1994.
10. M. Figel, IEC Validation Report 3.1 - Personal Dosimetry Service "AWST" Secondary Standard Dosimetry Laboratory "SSDL", Helmholtz Zentrum München (GmbH) – AWST, 2014
11. M. Kirr, *Fade Study of Al_2O_3:C Material*, March 2019
12. M. Moscovitch, *Personnel Dosimetry Using LiF:Mg,Cu,P*, *Radiation Protection Dosimetry*, Volume 85, Issue 1-4, 1 September 1999, Pages 49–56

References

13. L. Lou, *Extensive fade study of Harshaw LiF TLD materials,* Radiation Measurements, Volume 43, Issues 2–6, 2008, Pages 365-370
14. PNNL-15750 Rev. 0.2 PNL-MA-842, Hanford External Dosimetry Technical Basis Manual, August 2009
15. C. Passmore, Panasonic UD-802/UD-809 Fade Study, Rocky Flats Plant, 1991
16. IEC 62387:2020, *Radiation protection instrumentation - Dosimetry systems with integrating passive detectors for individual, workplace and environmental monitoring of photon and beta radiation*, January 2020
17. J. Vanos, *Evaluating the impact of solar radiation on pediatric heat balance within enclosed, hot vehicles.* Temperature, Volume 5, 2018
18. K. Becker, *Long-term stability of film, TLD, and other integrating dosimeters in warm and humid climates.* ORNL, 1973
19. M. Kirr, *Behavior of OSLN and OSL Material to Extreme Temperatures*, Landauer, March 2008
20. C. Passmore, *Behavior of BeO, LiF:Mg,Cu,P, $CaSO_4$:Tm, and $Li_2B_4O_7$:Cu Detectors Subjected to Extreme Temperatures*, Radiation Detection Company, June 2023
21. PNNL-15750 Rev. 0.2 PNL-MA-842, Hanford External Dosimetry Technical Basis Manual, August 2009
22. ABHP Website, 1998 Exam Part II Question, Section 9 - Past Part II Exams | The American Academy of Health Physics (aahp-abhp.org), 98exam.PDF (aahp-abhp.org)

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