DOELAP External Dosimetry Webinar

Dosimeter Fade

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Rick Cadogan
rcadogan@anl.gov
Phone: 630-252-3352

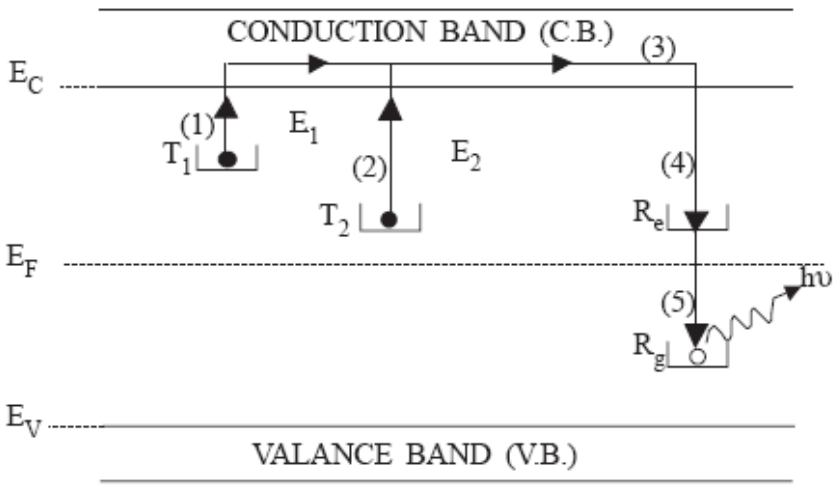
DOELAP On-Site Assessment Requirements Checklist

- TD.15 Luminescent material fading under normal conditions must be documented and accounted for over the period of intended use (dosimeter issue cycle).

- OSL.15 OSL material fading under normal conditions has been documented and accounted for the period of intended use.

Principles of Thermoluminescence or Optically Stimulated Luminescence

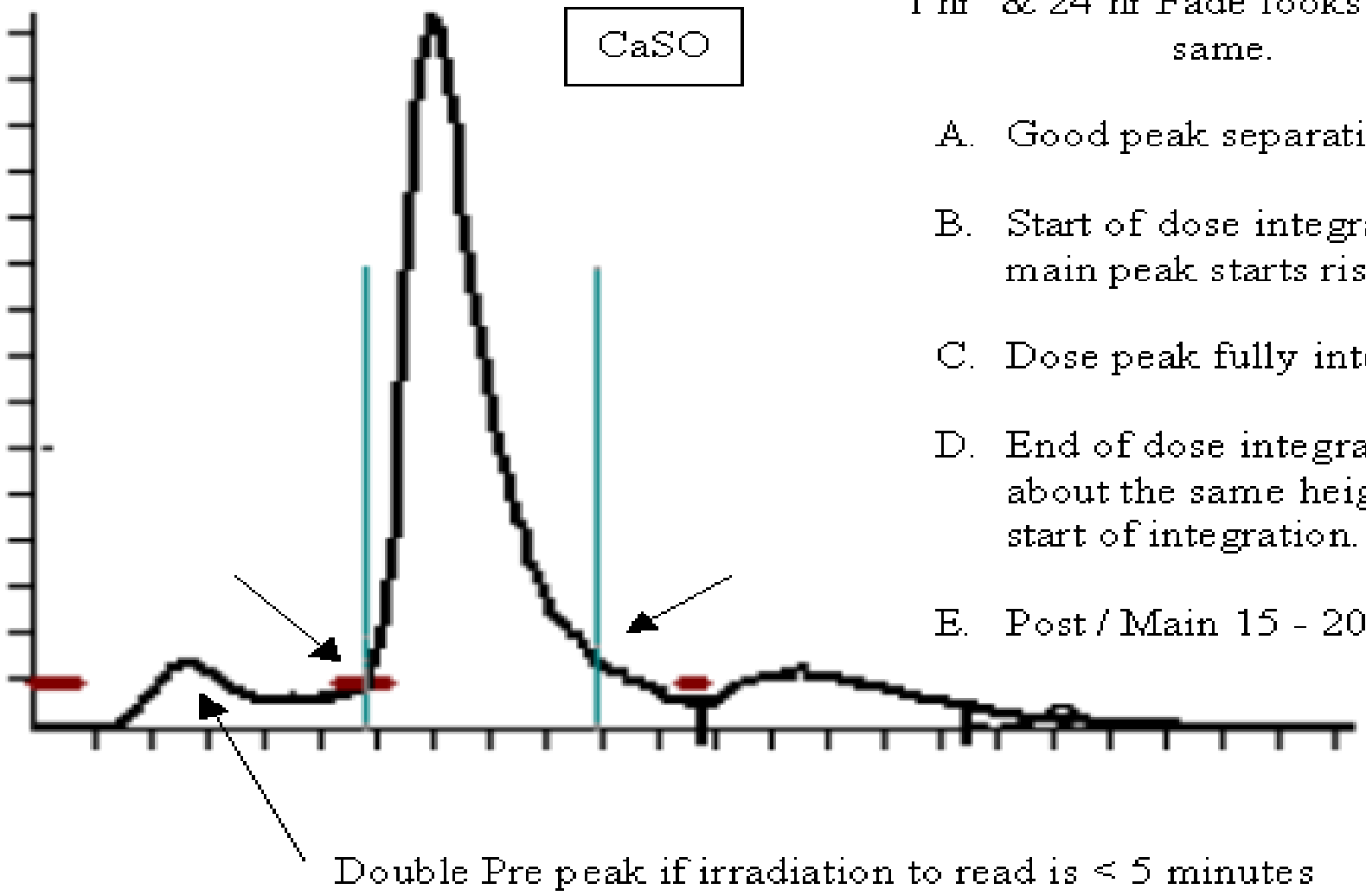
- Thermoluminscence (TL) or Optical Stimulated Luminescence (OSL) is the ability of some materials to convert the energy from radiation to a radiation of a different wavelength, normally in the visible light range.
- In some materials, defects in the material exist or impurities are added that trap electrons in the band gap.
- Trapped electrons have more energy than those in the valence band.
- When stimulated by heat or light, the trapped electrons return to the valence band giving off energy in the form of visible light.
- Measurement of the emissions (glow curve) allows for a conversion to dose equivalent.
- Trapped electrons are liberated due to ambient heat/light.



Fade Influences

- Integration of the ‘Dose’ portion of the glow curve
  - Timing Parameters - Panasonic
  - Region of Interest settings – Harshaw
- Heating intensity
  - Timing Parameters, Voltage, Bias Current - Panasonic
  - Ramp Rates - contact or hot gas – Harshaw
  - Ambient Temperatures (Lab storage vs Car dashboard)
- Sensitive element mass (Heat Capacity)
  - Amount of sensitive material, glue, substrate, moisture
  - Different manufactured lots may have different Heat Capacity

Good Heat Adjustment Techniques Reduce Fade Effects



1 hr & 24 hr Fade looks about the same.

A. Good peak separation

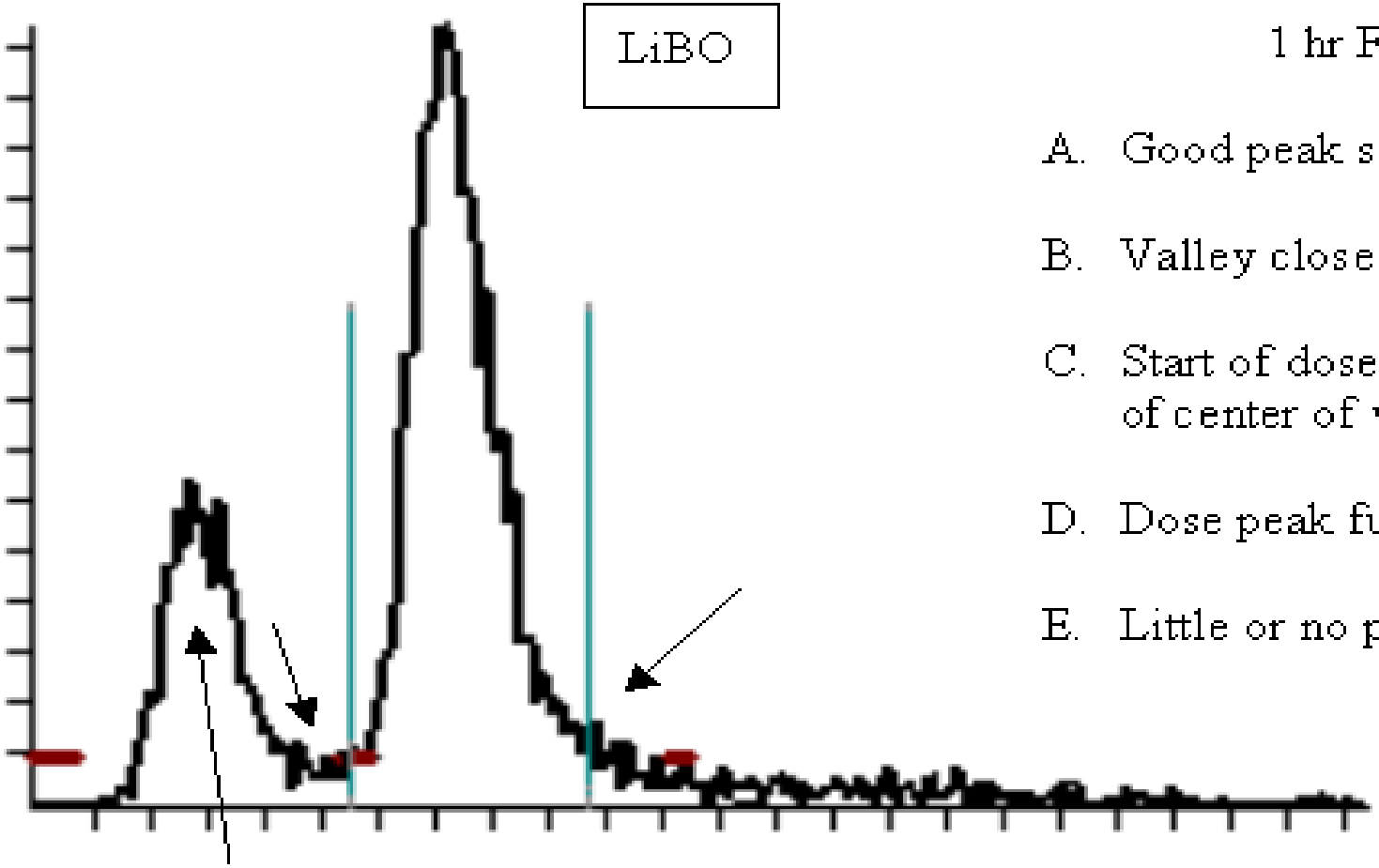
B. Start of dose integration after main peak starts rising

C. Dose peak fully integrated

D. End of dose integration at about the same height as the start of integration.

E. Post / Main 15 - 20%

Good Heat Adjustment Techniques Reduce Fade Effects



1 hr Fade

A. Good peak separation

B. Valley close to the base

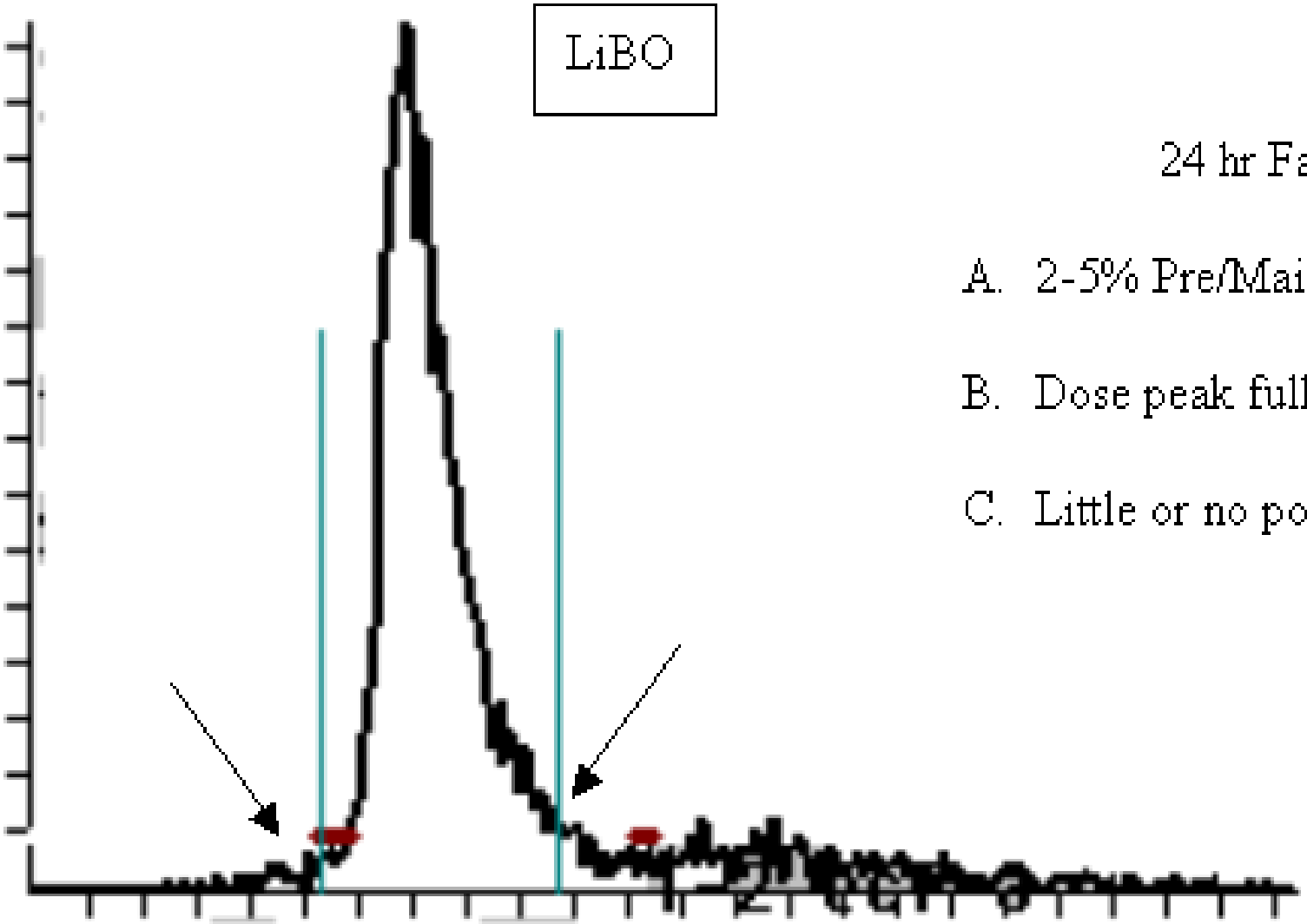
C. Start of dose integration right of center of valley

D. Dose peak fully integrated

E. Little or no post peaks

Shortly after irradiation, Pre & Main peak height should be ~ equal.

Good Heat Adjustment Techniques Reduce Fade Effects



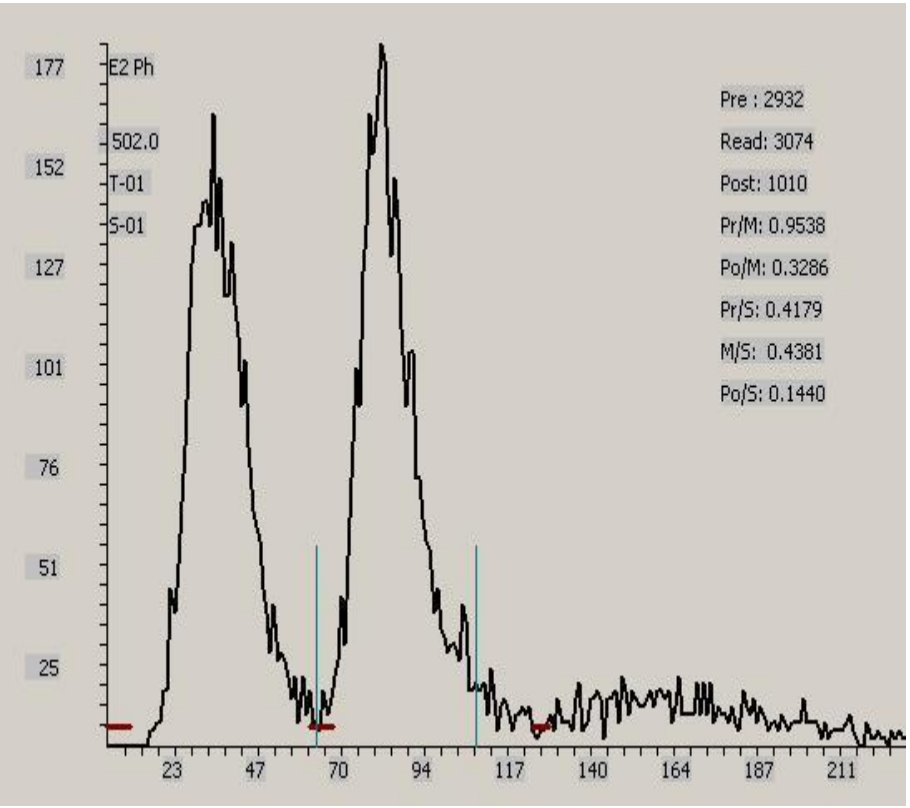
24 hr Fade

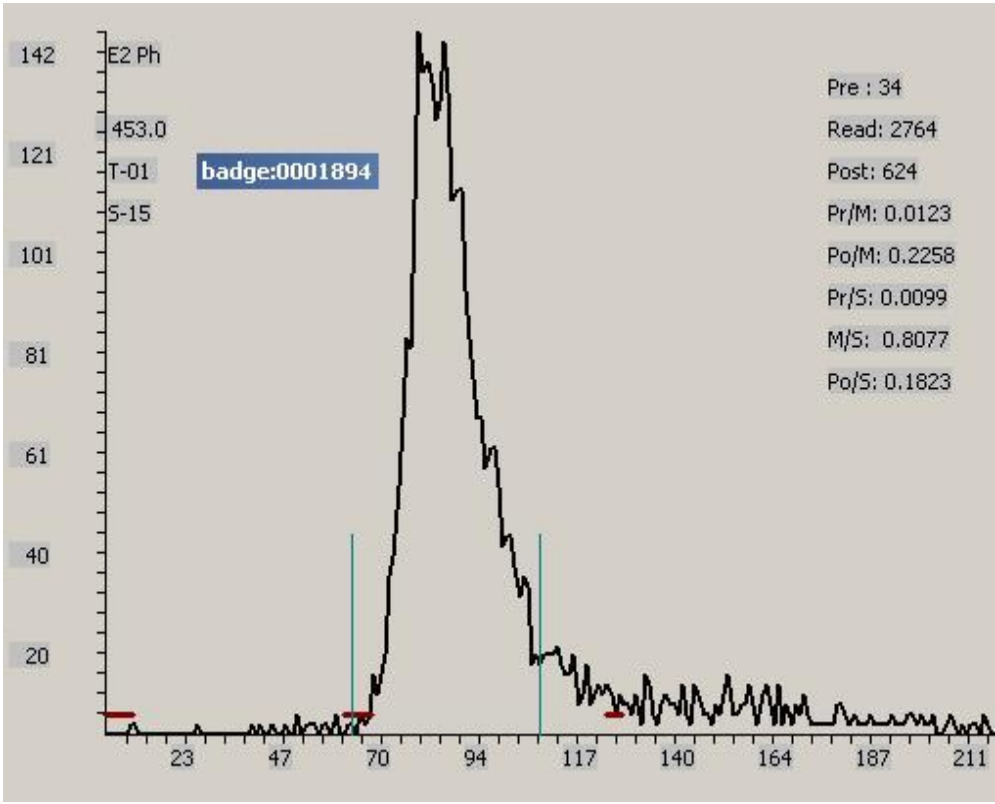
A. 2-5% Pre/Main counts

B. Dose peak fully integrated

C. Little or no post peaks

Integrated Glow Curves – Acceptable Heating



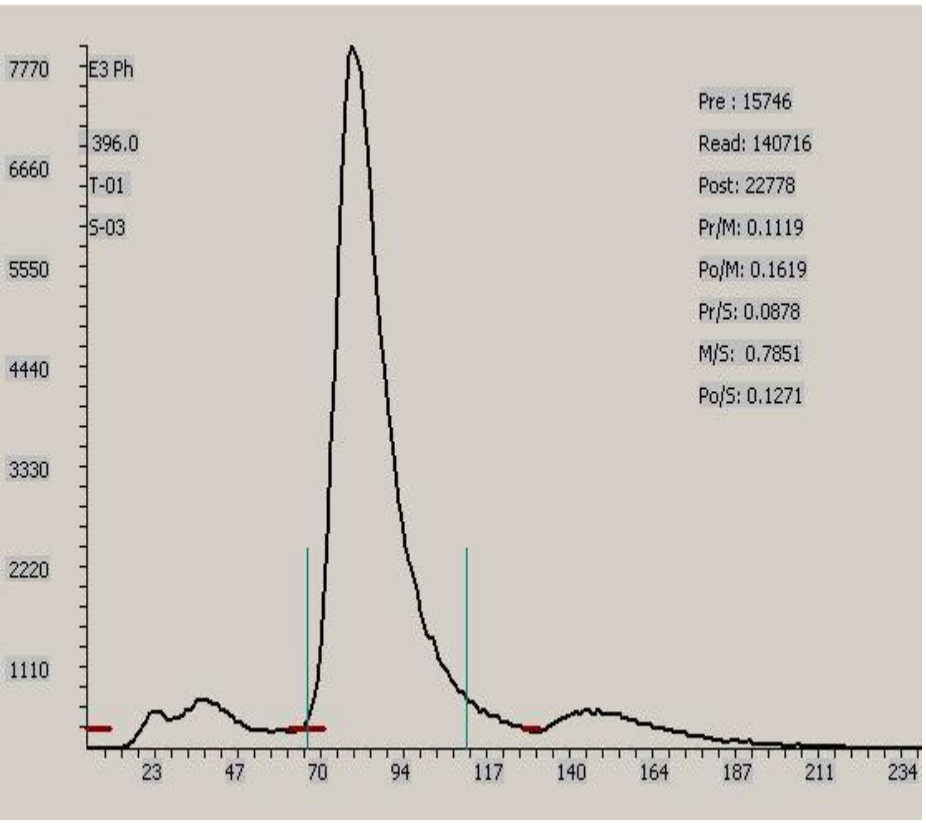


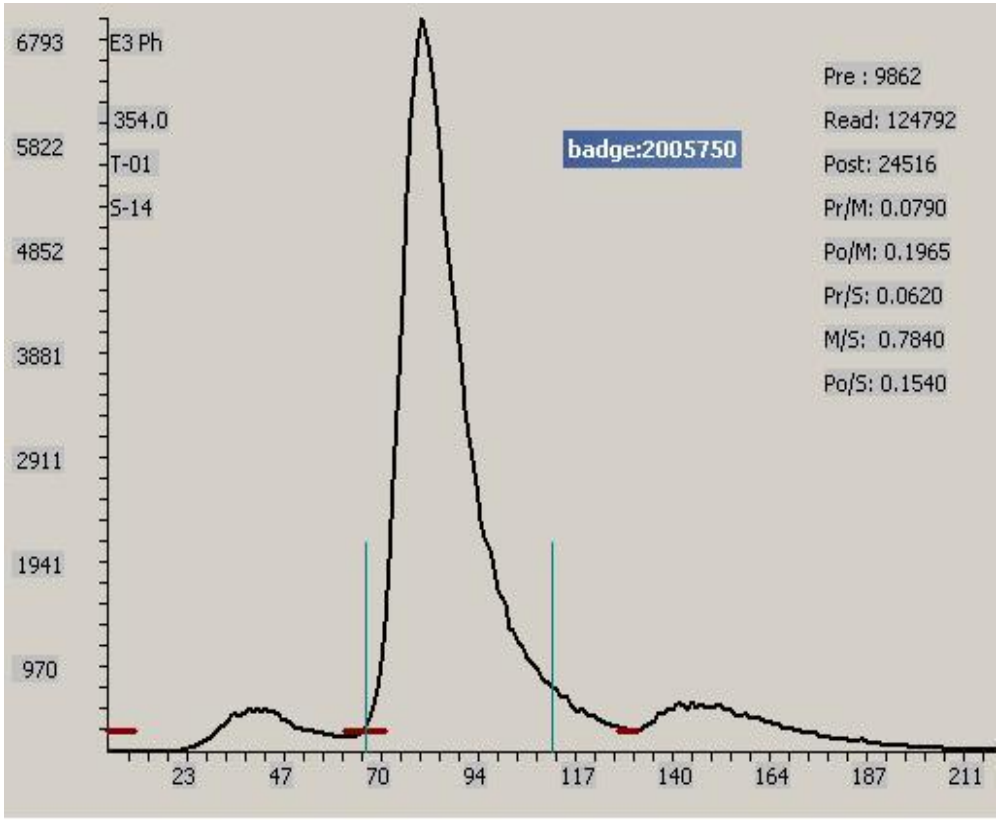
5 minute Fade

24 hr Fade

LiBO

Integrated Glow Curves – Acceptable Heating



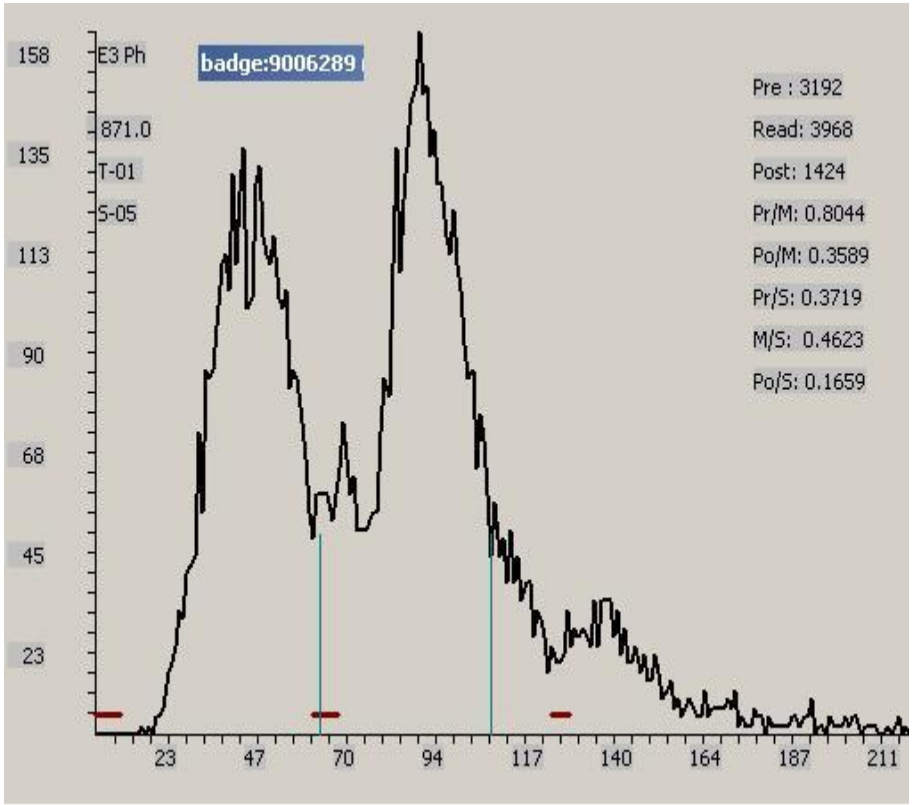


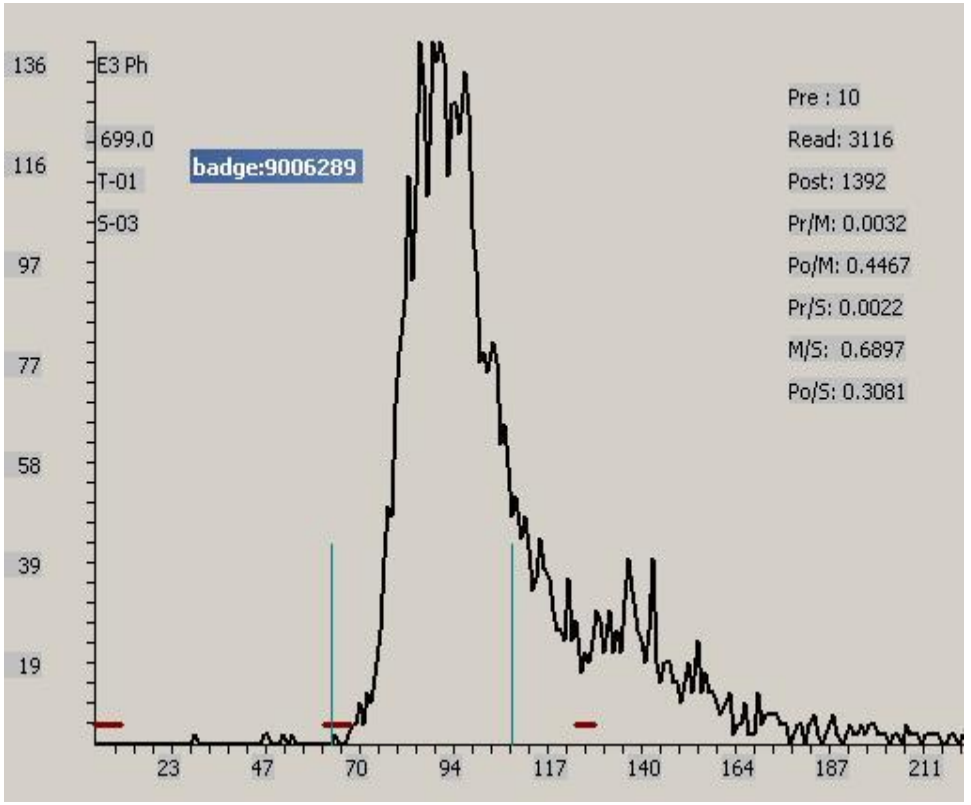
5 minute Fade

24 hr Fade

CaSO

Integrated Glow Curves – Improper Heating





5 minute Fade

24 hr Fade

LiBO

Verification of Acceptable Heating

UD-802		1 hr Fade					24 hr Fade					1 hr / 24 hr			
		E1	E2	E3	E4		E1	E2	E3	E4		E1	E2	E3	E4
2003805	2	800	791	498	497		769	765	483	484		1.040	1.034	1.031	1.027
2006083	2	821	820	536	545		793	804	512	519		1.035	1.020	1.047	1.050
2013363	2	833	812	557	637		833	820	553	632		1.000	0.990	1.007	1.008
2014076	2	668	653	665	668		655	631	633	659		1.020	1.035	1.051	1.014
2017805	2	589	408	499	533		607	417	470	500		0.970	0.978	1.062	1.066
2021491	2	613	609	510	538		600	569	486	511		1.022	1.070	1.049	1.053
2021909	2	483	506	534	421		474	499	516	412		1.019	1.014	1.035	1.022
2025550	2	512	411	730	741		505	392	701	697		1.014	1.048	1.041	1.063
2028627	2	343	392	606	656		332	398	577	620		1.033	0.985	1.050	1.058
2030273	2	395	325	653	643		405	315	611	587		0.975	1.032	1.069	1.095
											Ave	**1.013**	**1.021**	**1.044**	**1.046**
											Stdev	0.024	0.029	0.017	0.027

UD-809		1 hr Fade					24 hr Fade					1 hr / 24 hr (Fade Factors)			
		E1	E2	E3	E4		E1	E2	E3	E4		E1	E2	E3	E4
9003749	9	596	432	377	480		589	406	366	434		1.012	1.064	1.030	1.106
9005450	9	566	657	548	671		591	686	564	681		0.958	0.958	0.972	0.985
9007499	9	617	608	560	588		614	599	561	559		1.005	1.015	0.998	1.052
9010177	9	537	632	681	608		512	610	632	557		1.049	1.036	1.078	1.092
9010899	9	512	654	555	705		486	643	546	676		1.053	1.017	1.016	1.043
9015200	9	461	604	633	669		446	564	611	668		1.034	1.071	1.036	1.001
9016281	9	663	536	454	507		615	533	450	510		1.078	1.006	1.009	0.994
9022216	9	662	448	452	372		616	430	433	386		1.075	1.042	1.044	0.964
9023177	9	469	576	508	541		428	556	473	520		1.096	1.036	1.074	1.040
9026485	9	358	697	614	668		354	662	573	646		1.011	1.053	1.072	1.034
											Ave	**1.037**	**1.030**	**1.033**	**1.031**
											Stdev	0.042	0.033	0.035	0.046

Fade Definitions

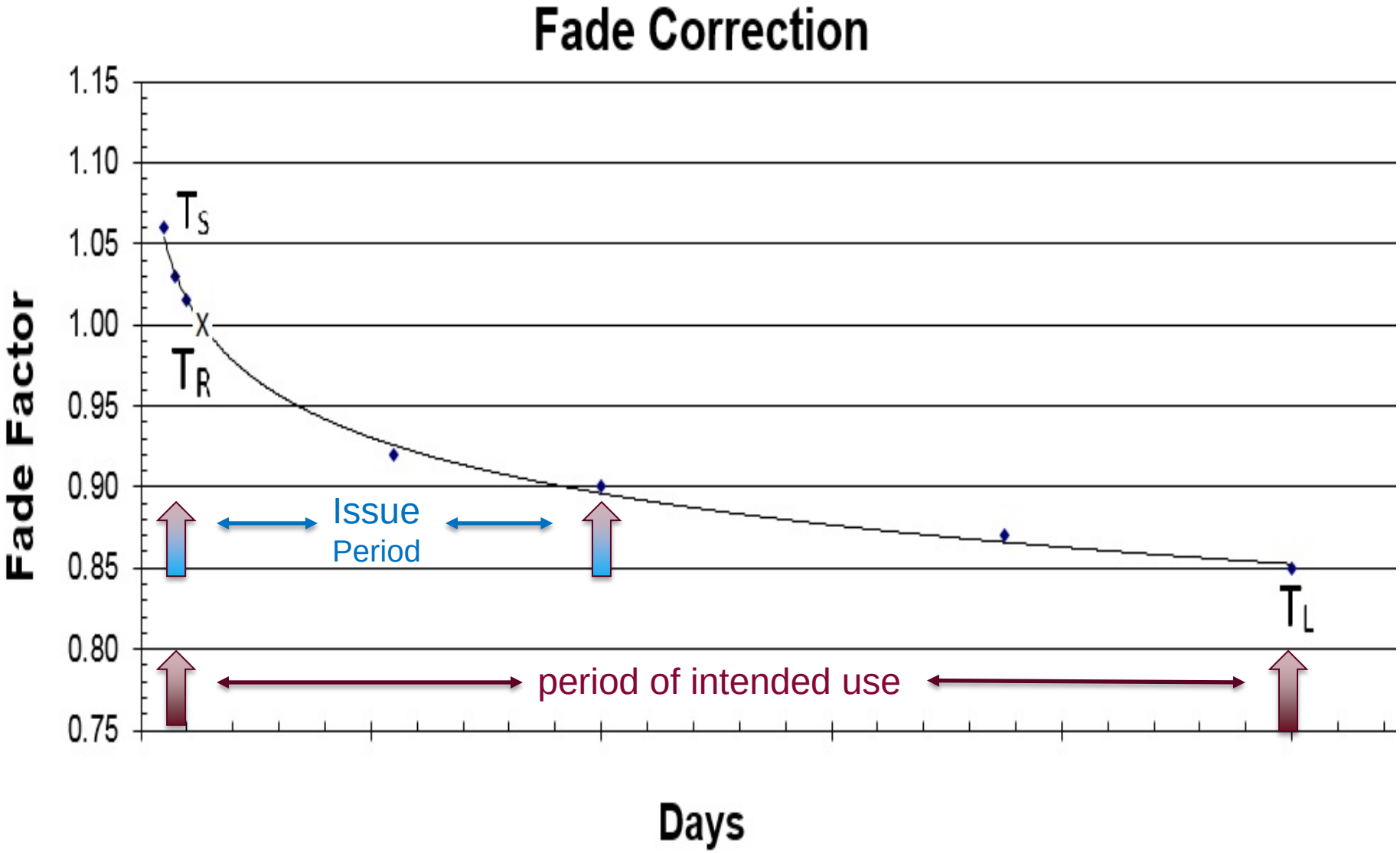
- Fade - Loss of signal due to ambient heat
- t_S – Shortest length of time between dosimeter irradiation and processing of the same dosimeter.
- t_R – Length of time between Irradiation and Calibration (16 – 48 hrs). Reference point for all other data points. Fade factor always considered 1.0. mR* = mrem
- t_L – Longest length of time between dosimeter irradiation and processing of the same dosimeter.
- t_x – Data point at any given location in time.

Fade Determination Methodologies

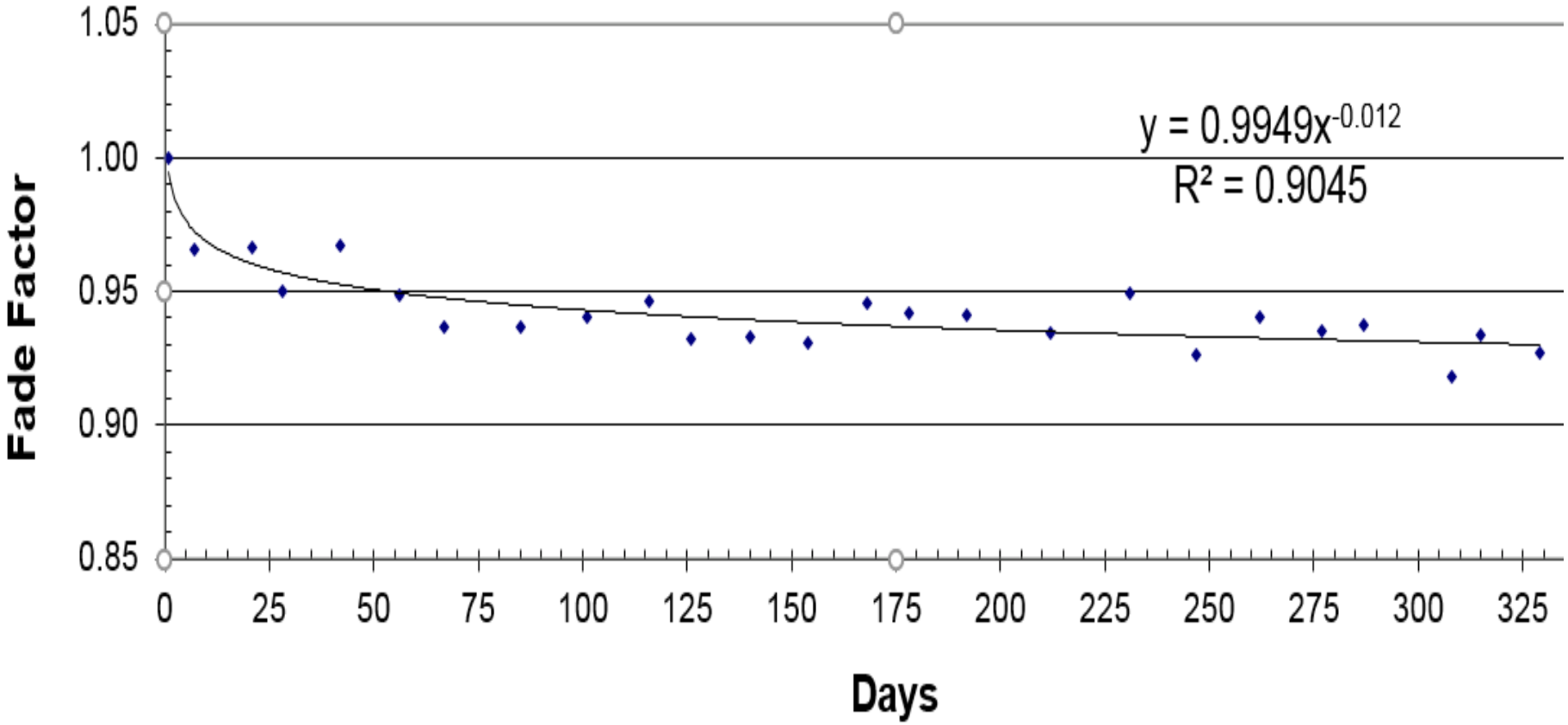
(Assumes no pre-fade issues)

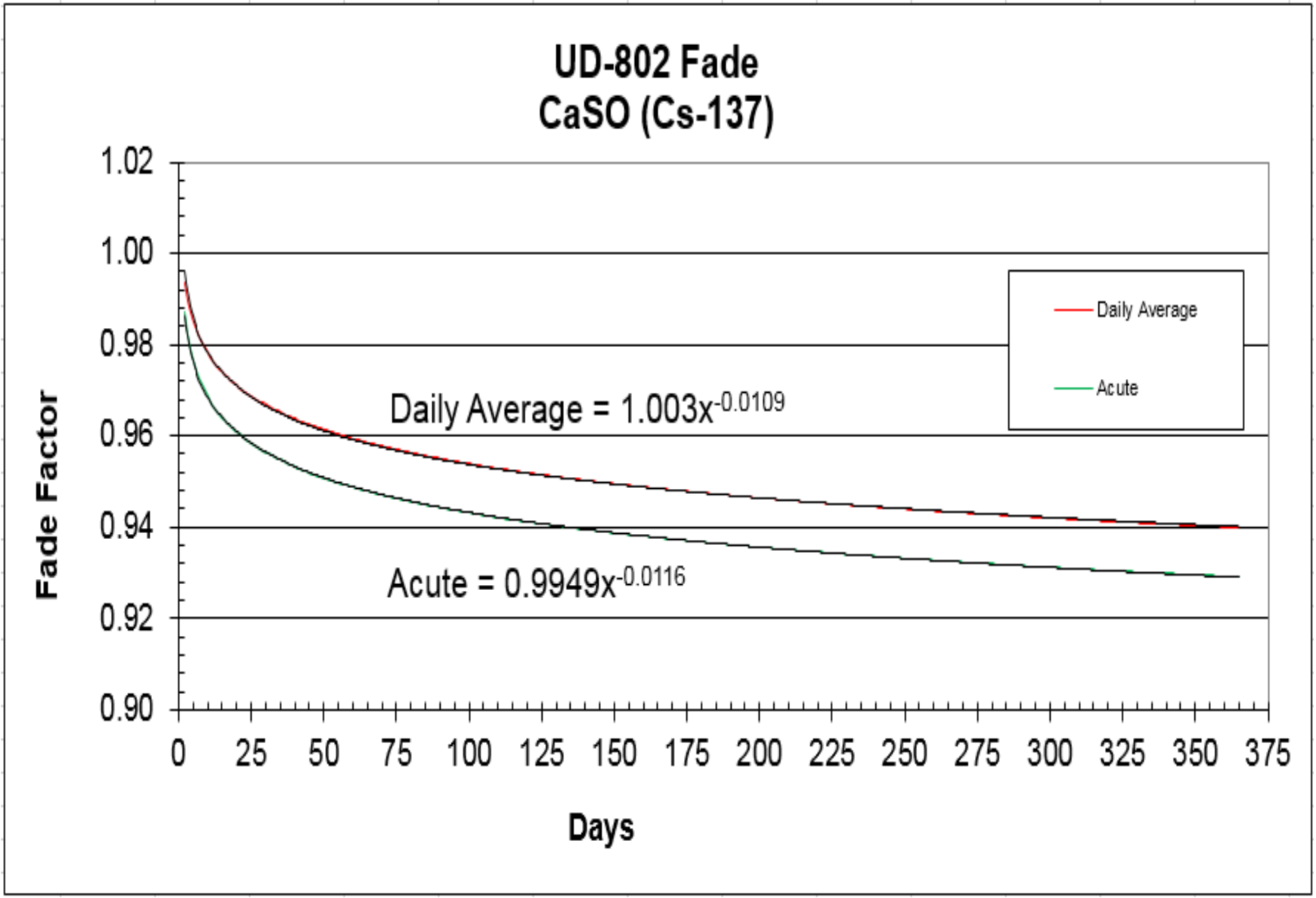
- Method #1
  - Irradiate all dosimeters at the same time to a know dose (i.e. 500 mrem)
  - Read irradiated dosimeters (5-10) at each predetermined fade point($\mathbf{t_x}$) with control subtraction.
  - Be sure to read irradiated dosimeters at routine calibration fade time ($\mathbf{t_R}$)
  - Calculate fade factor for each data point ($\mathbf{t_x}$ / $\mathbf{t_R}$)
  - Plot points (Fade Factor vs: Fade time) and calculate equation(s)

- Method #2
  - Irradiated dosimeters (5-10) at each predetermined fade point($\mathbf{t_x}$) (i.e. 500 mrem)
  - Be sure to include irradiated dosimeters at routine calibration fade time ($\mathbf{t_R}$)
  - Read all irradiated dosimeters at the same time with control subtraction. Read short term fade badges first.
  - Calculate fade factor for each data point ($\mathbf{t_x}$ / $\mathbf{t_R}$)
  - Plot points (Fade Factor vs Fade time) and calculate equation(s)


Fade Correction
Fade Factor
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
T_S
X
T_R
Issue
Period
T_L
period of intended use
Days

UD-802 Long-term Fade (CaSO) Cs-137
Acute




UD-802 Fade
CaSO (Cs-137)
Fade Factor
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
Days
Daily Average
Acute
Daily Average = 1.003x-0.0109
Acute = 0.9949x-0.0116

As an Assessor - ‘Finding’ or no ‘Finding’ Items to consider….

- Does the processor account for Fade?
  - If no; what is the Technical Basis for not using Fade Correction
- How is Fade Correction applied?
  - Acute, Daily Average, Mid-Point, Inherent Batch Correction or combination
  - Is Technical Basis Sound
- Is the Fade Correction reasonable for the time of intended use?
- Is the Fade Correction calculated and used past the routine issue periods?
- How long ago was a Fade Study performed?
  - Any recent validity testing?

References

- Panasonic Users Manual; Chapter 8; 12/18/1990
- Determining the Fade Correction for Panasonic Dosimeters; International Dosimetry and Records Symposium; Rick Cummings, PhD , June 2014
- Determination of Fade, EDG-409, Argonne National Lab, May 2008
- Heating Adjustments of the Panasonic UD-710A TLD Reader, EDG-410, Argonne National Lab, September 2009

Questions ?

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Discussion