

Annealing and Dose Decay Characteristics of OSLD's

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Abstract

The purpose of this work was to characterize annealing and dose decay characteristics of Optically Stimulated Luminescence Dosimeters (OSLD's) using the NMPC annealer compared to ambient clinic light. This required commissioning a new MicroSTAR ii system. To commission the MicroSTAR ii system, calibration OSLD's spanning the whole clinical range were irradiated, and quality control (QC) OSLD's for a subset were also irradiated. Calibration files were verified by reading the dose of QC OSLD's. To test decay by annealing, OSLD's with various residual doses were initially read with the MicroSTAR ii reader prior to annealing. The active portions of multiple OSLD's were exposed and placed into the NMPC annealer, and the dose was read periodically. To test decay by ambient clinic light, six OSLD's were also placed with different amounts of ambient clinic light to characterize the decay that took place. With the annealer, OSLD's with a larger starting dose required more annealing time to reach a background dose of 0.1 cGy. The dose on OSLD's with their active portions open to the ambient clinic light decayed faster than those that had less ambient clinic light exposure. Our recommendation is that OSLD's below 200 cGy need to be annealed for 45 minutes, between 200 cGy and 500 cGy need to be annealed 60 minutes, and between 500 cGy and 1000 cGy need to be annealed 90 minutes. Also, it is important not to leave OSLD's with their active portion left open to the light.

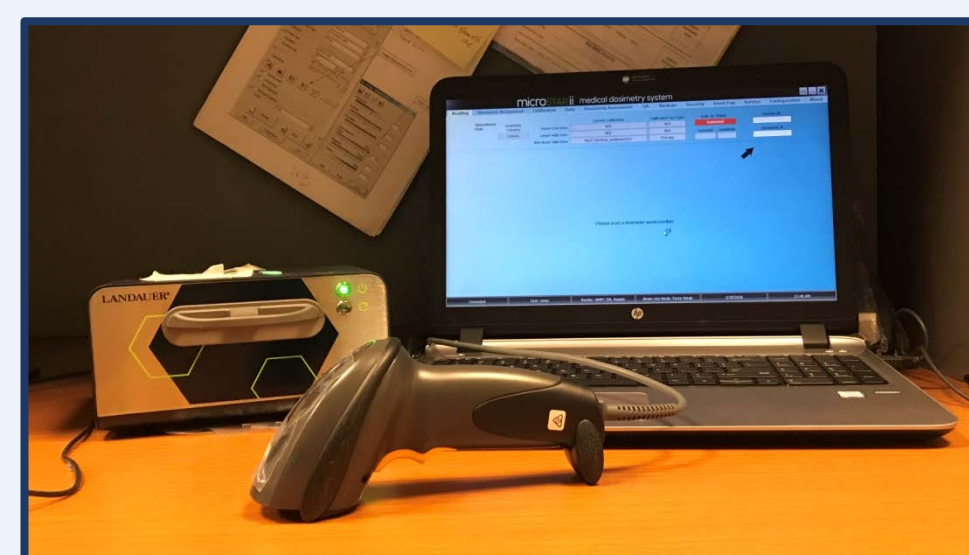
Equipment

1. NMPC In House Annealer

- 8 Blue Light Emitting Diodes (LEDs)
 - wavelength 440-445 nm for optical bleaching
 - high energy light more effective at releasing semi-stable electrons
- Holds up to 12 OSLD's
- Aluminum casing that acts as a heat sink.



2. MicroSTAR ii System



3. OSLD's

- Landauer Screened Nanodots used for all tests (see Fig 1). The tolerance for screened Nanodots is $\pm 5.5\%$
- Can be read multiple times, unlike Thermoluminescence Dosimeters (TLD's).
- Uses light to obtain reading as well as anneal, instead of heat.
- Handled with gloves to minimize contamination from oils and dirt on hands.
- Background dose on new OSLD is 0.02 cGy.

Methods

1. Commissioning MicroSTAR ii

- New calibration OSLD's were irradiated with both photons and electrons with doses from 0 cGy to 1300 cGy.
- QC OSLD's were irradiated for a subset of these doses at the same time as the calibration OSLD's and verified.
- The results were tabulated.

Methods Continued

2. Annealing Characteristics

- Annealing allows OSLD's to be irradiated and reused.
- Annealed using NMPC In House Annealer.
- OSLD residual doses used to test annealing times were about: 25 cGy, 200 cGy, 300 cGy, 500 cGy, 1000 cGy.
- The active portion of the OSLD was opened and exposed to the blue LED light in annealer.
- Throughout the annealing time, the OSLD's were taken out and read with the MicroSTAR ii system. The results are plotted in Graph 1.
- Clinically acceptable background dose of 0.1 cGy was chosen.



Fig 1. The "open" position was used when annealing and exposed to ambient clinic light (2).

3. Decay Characteristics

- 3 sets of 2 OSLD's were used:
 - 2 left with active portions exposed to ambient clinic light
 - 2 left with active portions closed in the ambient clinic light
 - 2 left in light proof sleeve under ambient clinic lighting
- Over the course of 26 days, the residual doses on the OSLD's were read with the MicroSTAR ii system and the doses were recorded. The results were tabulated and plotted (Graph 2).

Results

1. Commissioning MicroSTAR ii

- Good agreement was found between the expected doses and the QC OSLD doses.
- Linear calibration files used for < 200 cGy and nonlinear calibration files for ≥ 200 cGy.

green	$\leq 3\%$
yellow	3-5%
red	$>5\%$

Photon QC OSLD's MicroSTAR ii

Calibration file	100	150	200	250	300
Photons_Linear	98.2	143.7	200.6	254.3	312.5
Photons_Non Linear	106.1	145.8	196.4	240.8	293.3
Ratio Linear to Actual	0.98	0.96	1.00	1.02	1.04
Ratio Non Linear to Actual	1.06	0.97	0.98	0.96	0.98

Electron QC OSLD's MicroSTAR ii

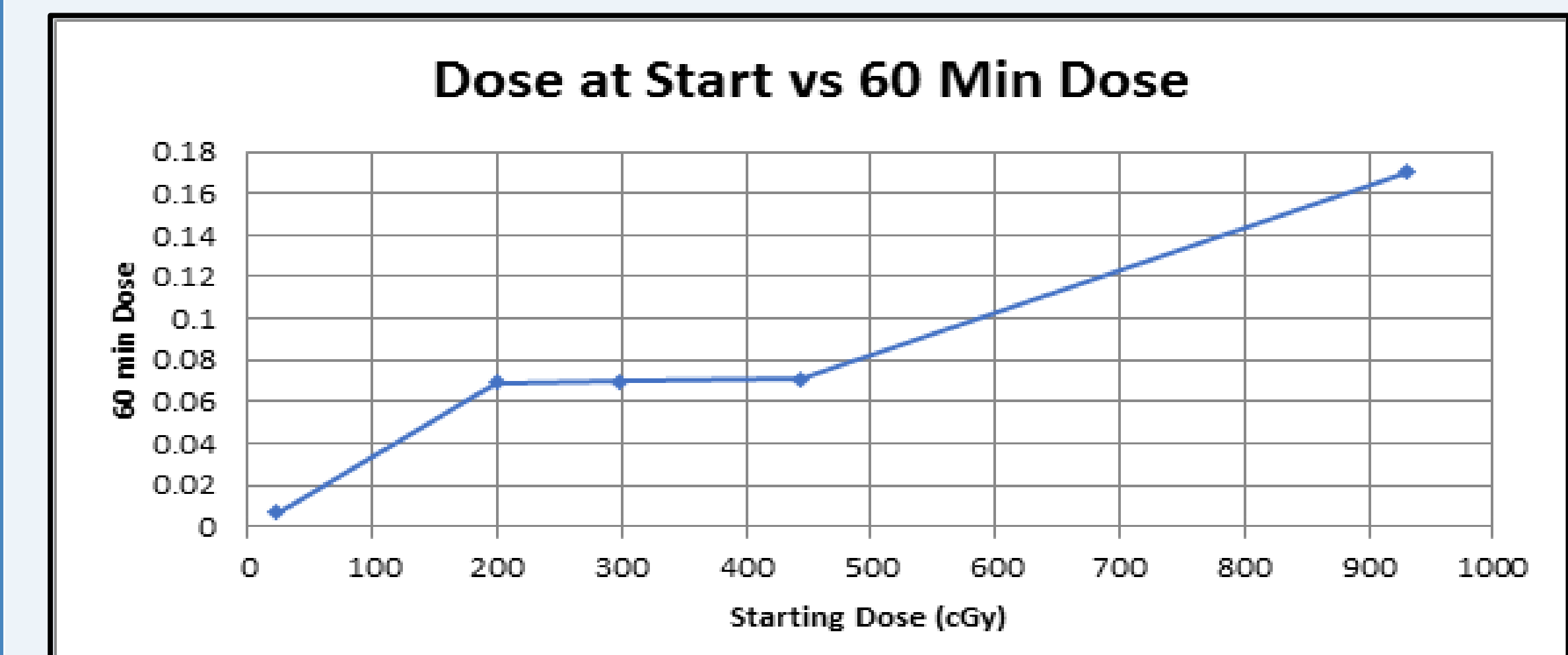
Calibration file	50	100	200	250
Electron_Linear	49.5	100.5	203	259.8
Electron_Non Linear	53.6	102.7	199.1	251.2
Ratio Linear to Actual	0.99	1.00	1.02	1.04
Ratio Non Linear to Actual	1.08	1.02	0.98	0.97

2. Annealing Characteristics

- OSLD's with a larger starting dose require a longer annealing time to reach an acceptable background reading of 0.1 cGy.

Annealing Time By Residual Dose	
Dose Range	Annealing Time
>200 cGy	45 min
200-500 cGy	60 min
500-1000 cGy	90 min

Results Continued

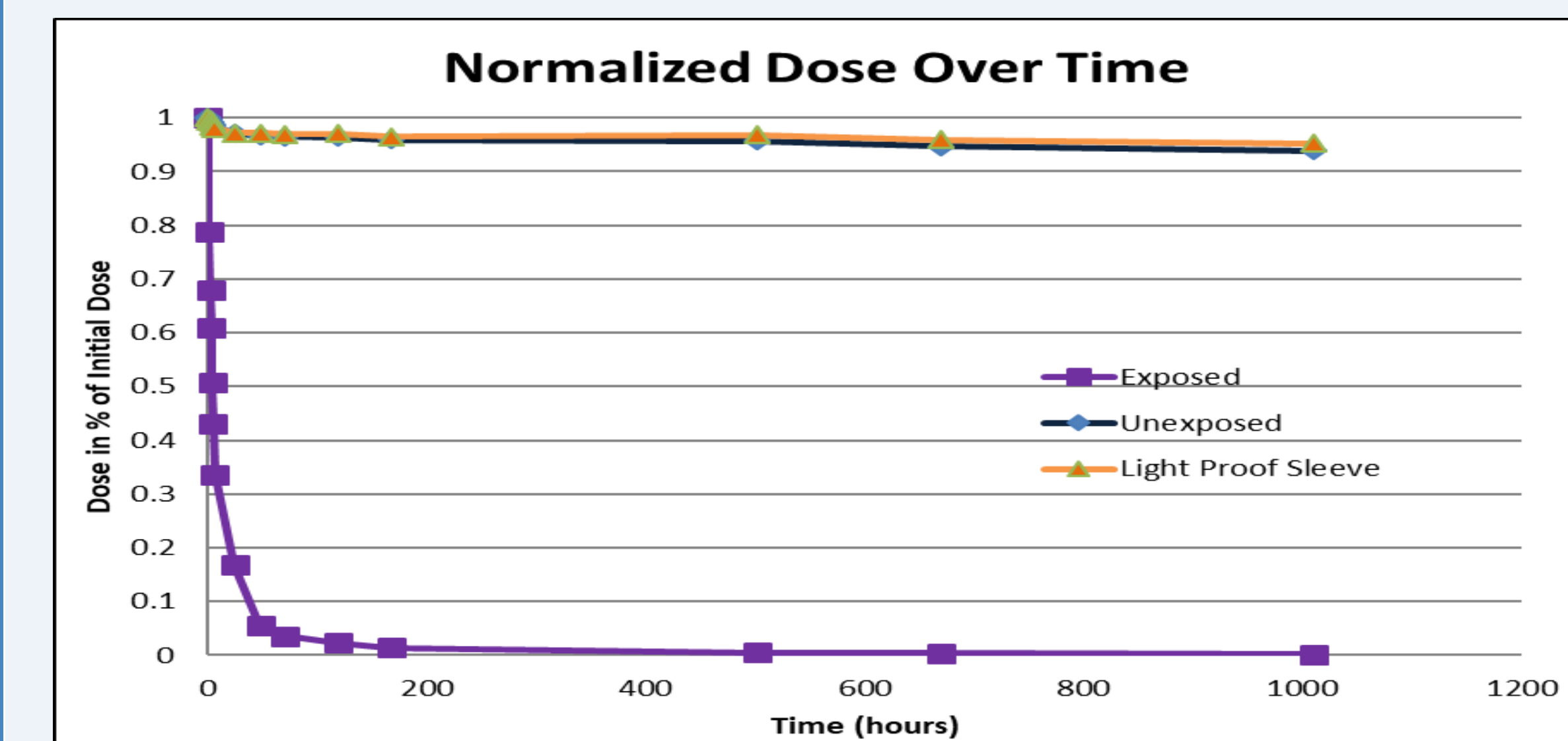


Graph 1. This graph depicts the residual dose on the OSLD versus the dose read with the MicroSTAR ii system after 60 minutes of annealing.

3. Decay Characteristics

- When the OSLD's were left with the active portion exposed to ambient clinic light, significant decay was observed compared with the OSLD's left unexposed to ambient clinic light

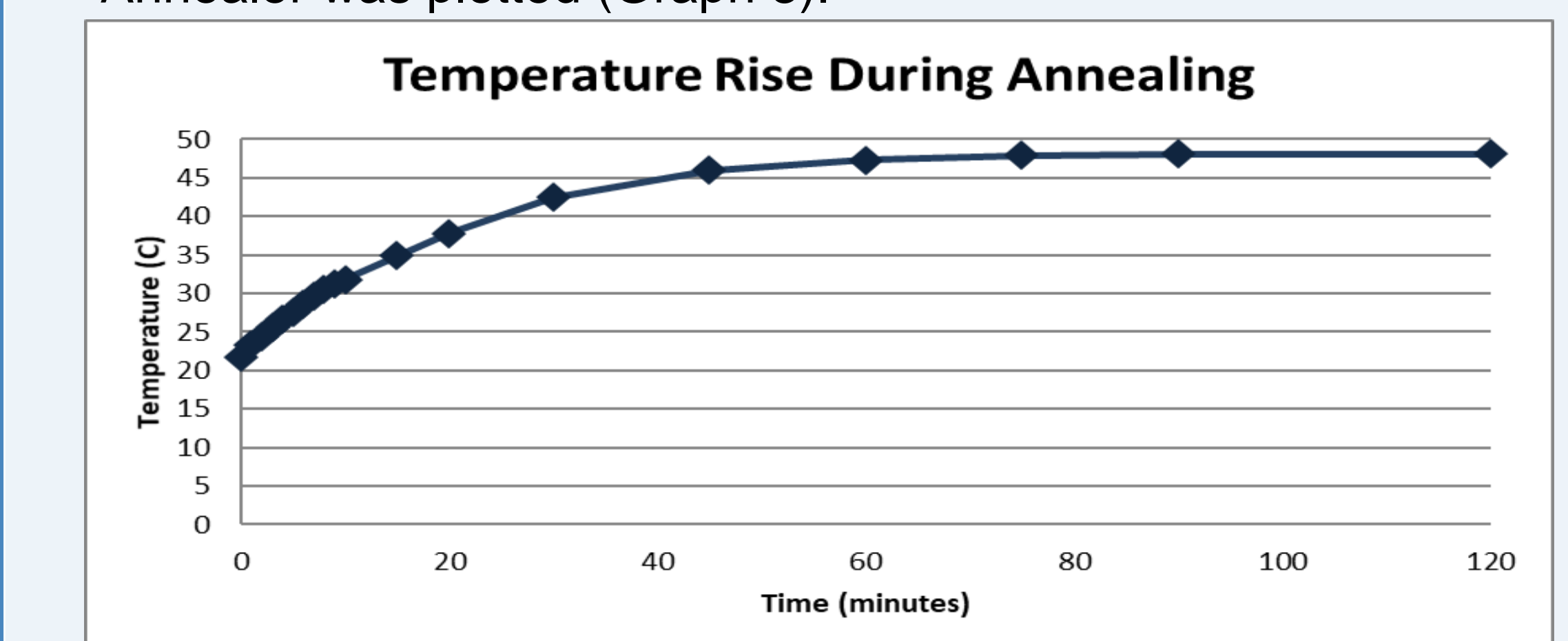
OSLD Condition	% Decay	Time (hours)
Exposed	99%	0.05
	50%	4.11
Unexposed	99%	3.12
	50%	N/A
Light Proof Covering	99%	4.29
	50%	N/A



Graph 2. This graph depicts the dose read normalized to the original dose on each OSLD over the course of a month.

3. Heat Management

- Temperature increase due to prolonged use of the NMPC In House Annealer was plotted (Graph 3).



Graph 3. This graph depicts the temperature rise of the annealer over the course of a two hour time period.

Conclusion

- Linear calibration files were best for doses >200 cGy and non linear for doses <200 cGy.
- Annealing time with the NMPC In House Annealer was 45-60 min for most clinically relevant doses.
- When the OSLD's were left with the active portion exposed to ambient clinic light, significant decay was observed compared with the OSLD's left unexposed to ambient clinic light.
- During prolonged annealing it is recommended that annealer be safely placed on metal surfaces.

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References:

- Jursinic, P.A., (2007) Characterization of optically stimulated luminescent dosimeters, OSLDs, for clinical dosimetric measurements. Medical Physics, 34(12):4594-604.
- Landauer. (2016) *MicroSTAR ii*: User Manual. Glenwood, IL.