Challenging Environmental TLD Posting Height Requirements

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Acknowledgement of Data

- Comparisons performed in 2004-2005
  - IPEC – Richard Colville, Tom Burns
  - Fitzpatrick – Barrie Gorman, Dave Baker
  - Pilgrim – Arnie Stearns
  - Progress Energy – Greg Barley
  - Robinson – Phil Boykin, Andy Wodarczyk
  - Brunswick – George Baird, Drew Petrusic

ANSI N545-1975 Requirement

- Title: *"Performance, Testing, and Procedural Specifications for Thermoluminescent Dosimetry (Environmental Applications)"*
- Section 6.3.1, Siting of TLDs:
  "In the field, the TLDs shall be suspended at a height of 1.0 ± 0.3 meters above the ground in a manner that will minimize the distortion of the radiation field."

ANSI/HPS N13.37-2013 (draft) Requirement

- Title: *"Environmental Dosimetry"*
- Section 7.1, Field Monitoring Locations:

"Standard monitoring locations should be at least 1.0 meters above the ground level, and where practicable, in line of sight of the monitored facility with brush and vegetation removed. The structure holding the dosimeter and the location should be chosen such that it will be available for the operating life of the monitored facility and not act as a shield between the dosimeter and the facility. Heights greater than 1.0 meter could be necessary at some locations to accommodate snow cover, theft, tides or other variables. Security or camouflage should be applied as necessary to minimize vandalism or damage by animal activity, but should not interfere with the performance of the dosimeters. If any of these provisions are applied, they should be applied consistently to the applicable monitoring location and documented. For example, the monitoring location should not be moved to a height of 2.0 meters in the winter and returned to a height of 1.0 meters in the spring, but rather remain at a constant position which allows for consistent year round monitoring."

Reality – Common Practice

- TLDs posted within easy reach are at risk of vandalism... is it better to meet 1-meter requirement and lose many TLDs, or post higher and recover more?
- 1-meter may be too low in areas of high snowfall
- Common practice is to post high enough to be out of reach, 2.5-3 meters
- Licensees are not alone... even NRC and state programs have adopted this practice
- Question: Does posting at >1-meter compromise integrity of measurements?

Basis of 1-meter Requirement?

- Standard height adopted for assessment of ground-deposited radioactivity
  - Regulatory Guide 1.109, Table E-6
  - EPA Federal Guidance Report 12
- “Whole body” dose? ...

  DOE DE91-013607, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance“

DOE DE91-013607, Section 5.5.5

"The recommended height for external radiation measurement is 1 m above the surface (footnote - Approximately the height of the gonads in adults standing or walking). If another height is used, the relationship to the 1-m height should be established and documented for the site. The frequency should be based on predicted exposures rates from site operations at the measurement locations. Integrating devices (e.g. dosimeters) should be exposed long enough (typically 1 calendar quarter) to produce a readily detectable dose (e.g., 10 x the minimum sensitivity of the dosimeter; for TLDs this would represent an exposure on the order of 5 to 10 mR). If intermittent external radiation measurements are made, their frequency should be timed to coincide with batch atmospheric releases or the intermittent use of large sources or the operation of radiation-generating facilities."

Exposure Components --What Does a TLD “See”?

- Cosmic Radiation
- Natural soil activity (K-40, U, Th)
- Ground deposition
- Noble gas, immersion+plume
- Direct radiation from plant
  - Steam/turbine skyshine
  - Waste storage, ISFSFI

Cosmic Radiation

- Somewhat dependent on latitude and elevation
- Doubles with every 5000-ft increase in elevation
- Yields 3 to 4 uR/hr, 25 to 35 mR/yr
- Affected by posting height?...
  Probably not

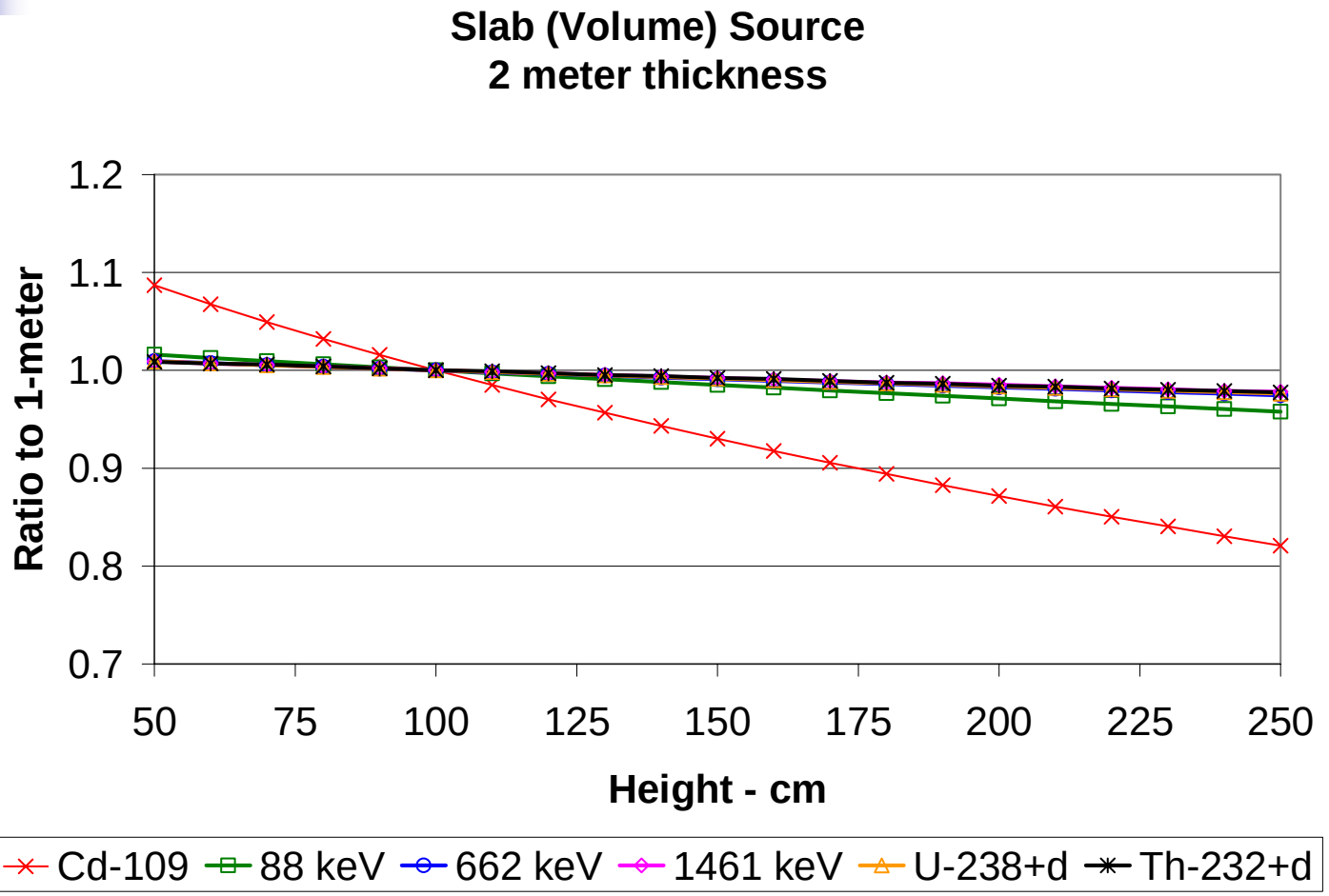
Natural Soil Activity

- Somewhat dependent on local geology
- K-40, U+progeny, Th+progeny
- Distributed throughout soil as volume source
- Yields 1 to 6 uR/hr, 9 to 55 mR/yr
- Affected by posting height?...
  Yes, but how much?

Effect of posting Height
Volume Source

- Performed MicroShield source-shielding calculation
- Assumed 2-meter thick soil slab, containing 15,000 pCi/kg activity for each of K-40, U-238+progeny, Th-232+progeny, Cd-109 (low energy, 88 keV), Cs-137
- Calculated exposure rates at heights from 50 cm to 250 cm in 10-cm increments
- Calculated ratio of exposure at each distance to exposure at 1-meter... normalized to “standard”

Exposure vs. Height
Volume Source

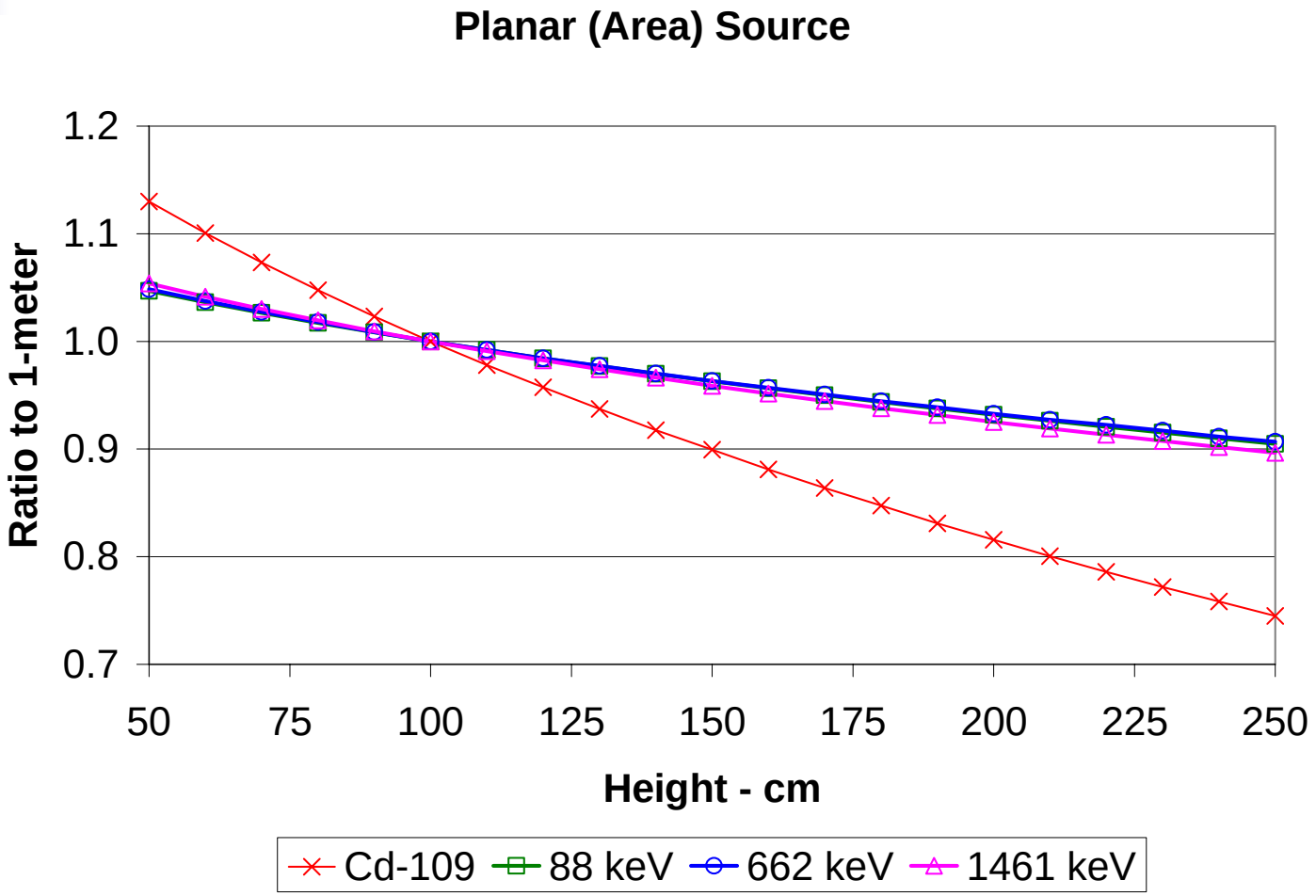


Ground Deposition

- Plant-related activity assumed to be deposited on surface as planar source
- Nuclide dependent... DCFs from Regulatory Guide 1.109, EPA FGR 12
- Negligible contribution from normal releases of plant effluents; important after accident?
- Affected by posting height?...
  Yes, but how much?

Exposure vs. Height

Planar (area) Source



Noble Gas

- Exposure can occur from immersion in radioactive cloud, and/or “shine” from adjacent plume
- Dependent on meteorology, distance, direction; elevated vs. ground-level release point
- Nuclide dependent... DCFs from Regulatory Guide 1.109, EPA FGR 12
- Negligible contribution from normal releases of plant effluents; important after accident?
- Affected by posting height?...
  Probably not

Direct Radiation from Plant

- Skyshine phenomenon, largely related to N-16 in steam, “contained” source, not an effluent... most problematic for BWRs
- Decreases rapidly with distance
- Can yield 15 to 40+ uR/hr in OCA between fence and site boundary, 120 to 350 mR/yr!
- Waste and fuel storage contribution probably lower
- Affected by posting height?...
  Probably not... or is it?

Study Design

- Study participants
  - Entergy Nuclear Northeast – Fitzpatrick, Indian Point, Pilgrim
  - Progress Energy – Brunswick, Robinson
- Post 3 TLDs at 1-meter, 3 TLDs at 2.5 meters, at each of 3 locations... 15 sets of co-located TLDs, 90 measurements per quarter
- Compare results, based on statistical analyses

Pilgrim Station TLDs – mR/qtr

Pilgrim	1m ± S.D.	2.5m ± S.D.	2.5-1.0 diff ± S.E.	Probability (diff = 0)
Loc. 1	29.5 ± 0.7	32.6 ± 2.8	3.1 ± 1.6	0.135
Loc. 2	30.4 ± 1.3	30.7 ± 1.9	0.3 ± 1.3	0.825
Loc. 3	135.9 ± 12.3	157.9 ± 14.0	22.1 ± 10.8	0.110
Loc. 1	21.6 ± 1.3	21.9 ± 0.5	0.2 ± 0.7	0.746
Loc. 2	21.8 ± 1.8	20.6 ± 0.8	-1.3 ± 1.0	0.242
Loc. 3	112.2 ± 7.9	161.1 ± 5.5	48.9 ± 4.8	**5.38E-05**

Fitzpatrick TLDs – mR/qtr

Fitzpatrick	1m ± S.D.	2.5m ± S.D.	2.5-1.0 diff ± S.E.	Probability (diff = 0)
Loc. 1	14.3 ± 0.4	13.9 ± 0.6	-0.4 ± 0.4	0.371
Loc. 2	44.7 ± 1.7	45.3 ± 0.3	0.6 ± 1.0	0.547
Loc. 3	19.2 ± 0.6	19.0 ± 0.8	-0.2 ± 0.5	0.748
Loc. 1	14.3 ± 0.7	14.8 ± 0.4	0.6 ± 0.4	0.283
Loc. 2	46.7 ± 1.0	48.3 ± 1.6	1.6 ± 1.0	0.204
Loc. 3	20.5 ± 0.3	20.5 ± 0.2	0.0 ± 0.2	0.864

IPEC TLDs – mR/qtr

IPEC	1m ± S.D.	2.5m ± S.D.	2.5-1.0 diff ± S.E.	Probability (diff = 0)
Loc. 1	25.5 ± 1.2	25.3 ± 1.1	-0.1 ± 0.9	0.885
Loc. 2	16.6 ± 0.3	18.3 ± 0.5	1.6 ± 0.3	**0.007**
Loc. 3	16.6 ± 0.4	14.7 ± 0.5	-1.9 ± 0.3	**0.005**
Loc. 1*	24.8	24.0	-0.8	--
Loc. 2*	16.1	16.4	0.3	--
Loc. 3*	15.9	15.8	-0.1	--

* Single TLDs posted during 1st quarter 2005

Brunswick TLDs – mR/qtr

Brunswick	1m ± S.D.	2.5m ± S.D.	2.5-1.0 diff ± S.E.	Probability (diff = 0)
Loc. 1	10.0 ± 0.4	9.9 ± 0.2	-0.1 ± 0.2	0.709
Loc. 2	10.9 ± 0.2	10.7 ± 0.2	-0.2 ± 0.2	0.210
Loc. 3	9.2 ± 0.4	9.2 ± 0.3	0.0 ± 0.3	0.907
Loc. 1	9.7 ± 0.2	9.9 ± 0.2	0.1 ± 0.1	0.345
Loc. 2	10.6 ± 0.2	11.6 ± 0.8	1.0 ± 0.5	0.103
Loc. 3	9.2 ± 0.2	10.5 ± 0.9	1.3 ± 0.5	0.065

Robinson TLDs – mR/qtr

Robinson	1m ± S.D.	2.5m ± S.D.	2.5-1.0 diff ± S.E.	Probability (diff = 0)
Loc. 1	12.5 ± 0.2	11.8 ± 0.4	-0.8 ± 0.2	**0.037**
Loc. 2	12.6 ± 0.3	12.5 ± 0.1	-0.1 ± 0.2	0.607
Loc. 3	9.2 ± 0.3	9.4 ± 0.1	0.2 ± 0.2	0.210
Loc. 1	12.7 ± 0.3	12.0 ± 0.6	-0.7 ± 0.4	0.179
Loc. 2	13.3 ± 0.1	13.2 ± 0.5	-0.1 ± 0.3	0.750
Loc. 3	10.5 ± 1.5	10.5 ± 0.5	0.0 ± 0.9	1.000

Summary

- 26 of 30 posting height differences were ***not*** significant at the 95% confidence level.
  - +1.6 mR/qtr at P=0.007
  - -1.9 mR/qtr at P=0.005
  - -0.8 mR/qtr at P=0.037
  - +48.9 mR/qtr at P=5.4E-5... *high degree of skyshine*
- Both positive and negative differences were noted in posting at 2.5m vs. 1m... that is, there was no consistent pattern.

Summary (continued)

- At locations where there may be an appreciable contribution from skyshine (BWR turbines, ISFSFI), posting at a greater height may yield higher exposure due to less shielding by brush and trees.

Conclusion

- There does not appear to be compelling statistical evidence to require a standard posting height requirement of 1 meter above the ground.
- Benefits gained by posting at a greater height, such as decreased vandalism, would appear to outweigh any small differences in exposure due to posting height.

Conclusion (continued)

- It will be left up to individual licensees to determine if they will choose to conform to the 1-meter standard posting height from ANSI-N545-1975
- ANSI/HPS N13.37-2014 provides more latitude in posting heights to accommodate issues related to snow, theft, etc.