Nuclear Power Plant Data Analysis for InLight LDR Model 2 Dosimeter

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INTRODUCTION

Landauer services approximately 75,000 nuclear power plant (NPP) workers worldwide using the InLight Analytical System composed of InLight LDR Model 2 whole body dosimeter and InLight Reader. Servicing these NPP workers provides an excellent repository of occupational radiation worker dose and dosimeter response data for this industry.

The InLight LDR Model 2 dosimeter has become very popular in nuclear power industry by proving accurate dose results in challenging radiation fields, enabling long wear periods due to its negligible fade and the ability of providing accurate incremental dose results during the wear period without impacting the final dose. The dosimeter contains four discs of Al_2O_3:C placed under different filters for improved energy response and energy discrimination. InLight Reader uses Continuous Wave Optically Stimulated Luminescence (CW-OSL) to interrogate the dosimeter and provide an output signal directly proportional to the amount of ionizing radiation that interacted with the dosimeter.

Dose results from the NPP industry segment were studied to determine opportunities to enhance dosimeter system performance, catalogue radiation fields and dosimeter response, determine trends, and document experiences within the NPP market segment.

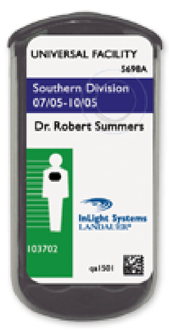
OBJECTIVES

Review InLight LDR Model 2 dosimeter data from NPP industry to assess opportunities to enhance dosimeter performance.

METHODS

Overview

Approximately 26,000 dosimeter results and element responses were assembled from USA NPPs. The data set included the gross response (background radiation response not subtracted) of the four dosimeter elements within the dosimeter. Dosimeter results with final reported *Hp(10)* less than or equal to 1 mSv (100 mrem) were included in the data set. Higher doses were excluded to avoid including non-occupational dosimetry results from blind audit, area monitoring, and field testing in the data set.



Dosimeter Configuration

Landauer Holder

XA case with 4 filters
Open window = OW = E1
Plastic = PL = E2
Aluminum = Al = E3
Copper = Cu = E4

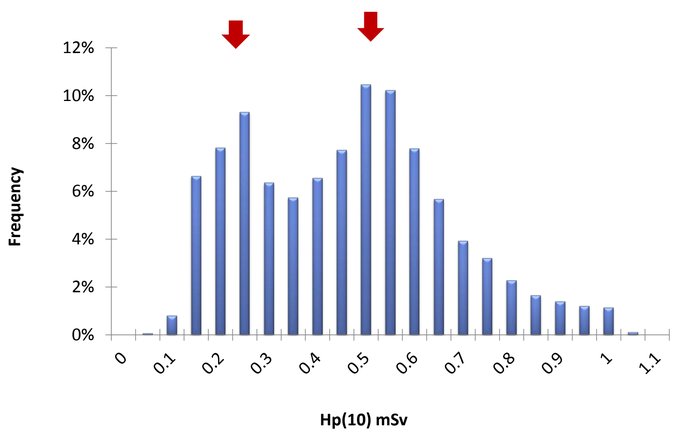
A type slide with 4 Al_2O_3:C detectors

Dose Calculation Algorithm Summary

Algorithm calculates 2 preliminary *Hp(10)* doses using E2 and E4. Ratio E3/E4 (R34) is used to determine which *Hp(10)* dose will be reported. Depending on the R34 ratio one of the following will be used to report the final *Hp(10) result.*

HdPREDE2 Branch used to assess *Hp(10)* when R34 less than 1.05	• *High energy photon field identified (>250 keV)* • Report based on net E2
HdPREDE4 Branch used to assess *Hp(10)* when R34 greater than 5	• *Low energy photon field identified (<40 keV)* • *Report based on net E4*
Average of HdPREDE2 and HdPREDE4 when R34 is between 1.05 and 5	• *Mixed photon field or medium energy identified* • *Report based on net E4 & net E2*

RESULTS

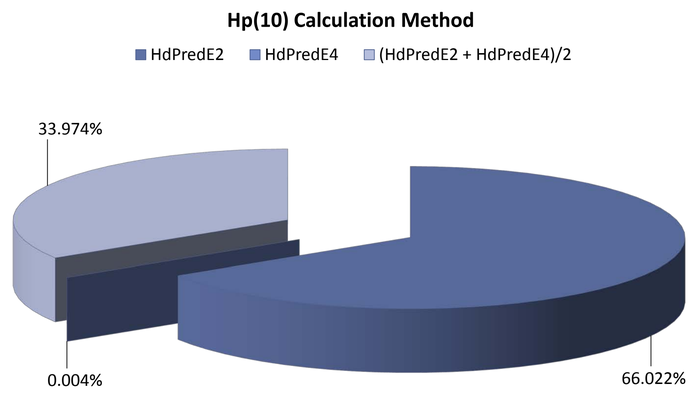


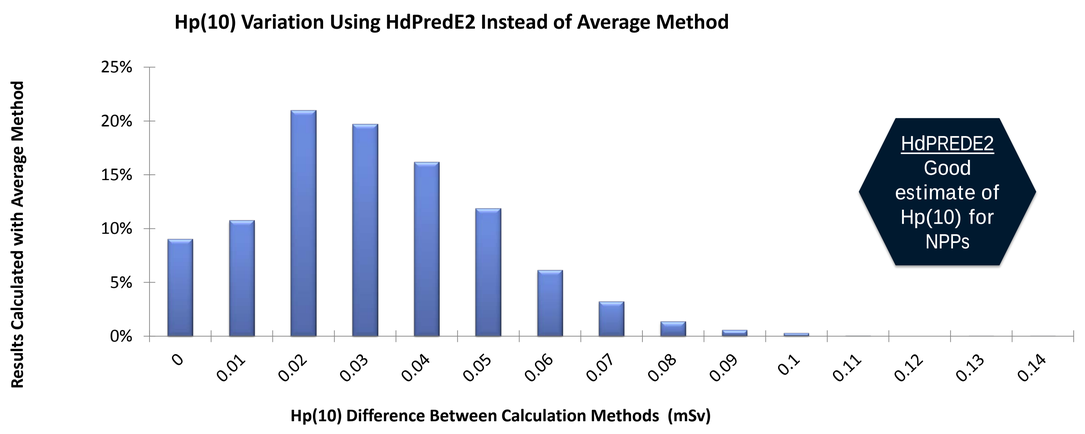
Data set followed a bimodal distribution with distinct peaks (local maxima) in the probability density function at 0.25 mSv (25 mrem) and 0.52 mSv (52 mrem).

Bimodal distribution indicates 2 work groups (radiation workers and non-radiation/infrequent workers)

RESULTS (cont.)

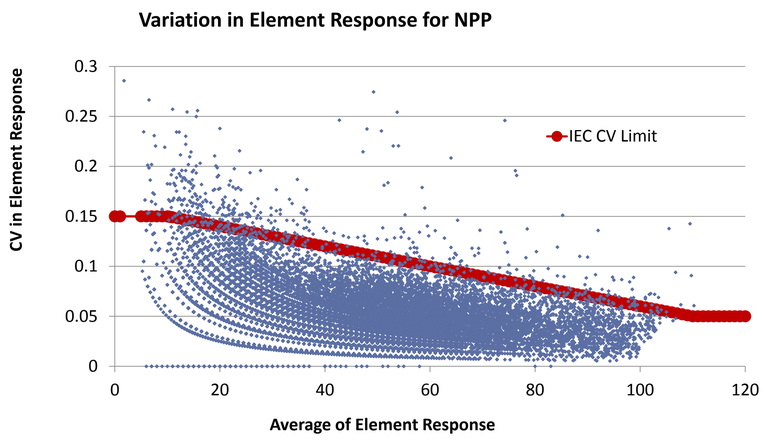
HdPREDE2 calculation method was used 66.02% of the time and averaging method was used 33.97% of the time.





Average of HdPREDE4 & HdPREDE2 results recalculated as HdPREDE2

41% within 0.02 mSv (2 mrem)
88% within 0.05 mSv (5 mrem)
No change for 9% of the results



The average of 4 element readings and coefficient of variation (CV) was plotted against IEC 62387-1:2007 CV criteria.

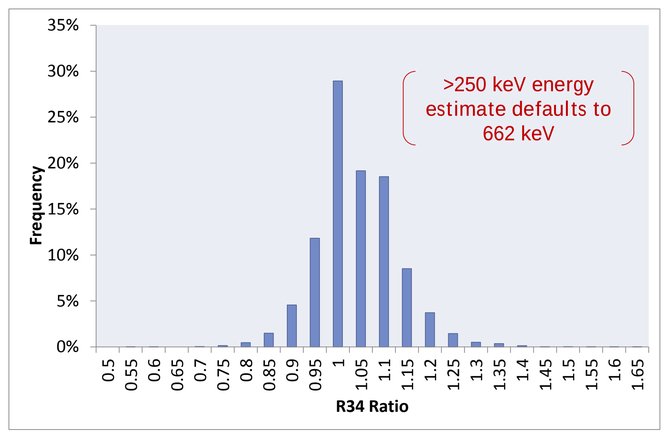
Average of element readings could make a good algorithm for NPPs

CV < 0.1 for 92.5% of readings

Dosimeter could be used as a crude spectrometer based on R34.

Algorithm provides an estimate of the photon energy based on R34

R34 falls between1.020 to 1.023, 95% of the time which indicates photons greater than 250 keV.



Since a majority of dose results from this market are high energy photon and coefficient of variation (CV) between element readings are low, even a very simple linear algorithm could be viable, Equation 1.

Equation 1

$$Hp(10) = Hp(3) = Hp(0.07) = (PL/0.98 + Cu/0.98 + Al/0.98) / 3$$

CONCLUSIONS

The InLight LDR Model 2 dosimeter system is very robust in handling nuclear power plant (NPP) radiation fields. Over 80% of the dose results were within a few µSv of each other regardless of the calculation method used to report the *Hp(10)*. The ratio of E3/E4 appears to be a good decision point for this market segment and there is enough overlap between the dose calculation methods to provide similar dose results regardless of the calculation method used.

Studying the dosimetry results has led to enhanced detection of abnormal dose results from NPPs through proactively identify dosimeters for reanalysis based on E3/E4 ratios outside of observed ranges. Dosimeter results outside the expected E3/E4 range have a high probability of triggering discrepancies between active and passive dosimeters.

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