ULTRA-LOW TO MODERATE INTENSITY SPECTROMETRIC NEUTRON DOSIMETRY WITH H*10-TMFD vs ROSPEC, EBERLINE, AND LUDLUM DETECTOR SYSTEMS

Presenter

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This paper presents results of studies conducted at Savannah River Site pertaining to ultra-low through moderate intensity neutron dosimetry with spectrometry enabled panel of tensioned metastable fluid detectors (TMFDs) and compared against state-of-art systems. H*10 neutron dosimetry (unlike for gamma dosimetry), requires consideration of neutron energy spectra due to the 20x variation of the weight factor over the thermal-to-fast energy range, as well as the neutron radiation field dose rates ranging from cosmic (~μRem/h) levels to commonly encountered ~10-20 mRem/h in nuclear laboratories /processing plants, and upwards of 10^6 Rem/h in nuclear reactor environments. This paper discusses the outcome of comparison of spectrum-weighted neutron dosimetry covering thermal-to-fast energy using the novel H*-TMFD spectroscopy enabled sensor system in comparison with measurements using state-of-art neutron dosimetry systems at SRNS – Rotating Spectrometer (ROSPEC™), and non-spectroscopic Eberline ASP2E™ (hereafter, "Eberline") and Ludlum 42-49B™ (hereafter, "Ludlum") survey instrumentation. The H*-TMFD was validated for gamma blindness using a 0.67 Ci Cs-137 source and the background dose rate in SRS's low-scatter facility (LCF) with all neutron sources withdrawn was estimated at ~ 0.5 μRem/h. Thereafter, moderate and ultra-low radiation field neutron dose assessments were conducted for spectroscopic and survey mode neutron dosimetry with H*-TMFD, ROSPEC, Eberline and Ludlum devices.

From moderately high radiation fields tests conducted with the high intensity ($1.6x10^9$ n/s) Cf-252 source and a total data collection time of ~0.15 h the predicted dose rates from Eberline (non-spectroscopic), Ludlum (non-spectroscopic) and spectroscopic H*-TMFD instruments were found to be: ~17 mRem/h, ~20 mRem/h, and ~12 mRem/h, respectively. The equivalent spectroscopic (SRS measured) H*10 dose rate from ROSPEC value is ~ 13 mRem/h which is within 10% of H*10-TMFD measurement. Unfolded neutron energy spectra comparisons indicated good agreement of the ROSPEC and H*10-TMFD predictions against that for a bare Cf-252 spectrum with some down scattering effects. Tests conducted for ultra-low intensity radiation field used a ~$1.6x10^3$ n/s Cf-252 bare neutron source for which over a collection time of ~18 h, the Eberline meter measured an instantaneous dose/count rate of 0 mRem/h (0 cpm), and a pulse- integrated dose rate of ~3.4 μRem/h at ~1 m. In contrast, The H*-TMFD panel located 0.22 m in direct line of sight of the Cf-252 source spectroscopically measured ~40 μRem/h (within +/- 5%) over 1.8 h collection live time -for which spectrum matched perfectly to that of a bare Cf-252 source. The H*TMFD predicted value of 40 μRem/h was cross-checked; it is within 10% of LLNL's published value of ~37 micRem/h (intensity / distance corrected via $1/r^2$ law of: 2.55 mRem/h at 1 m for a 1 μg Cf-252 source); as well, predicted from use of ICRP-74 conversion coefficients, and MCNP code simulation of experiment. Epithermal neutron energy related dose rates were measured by H*TMFD to be well below 1% of the total dose rates. For μRem/h neutron radiation fields, ROSPEC measurements for H*10 dose rates are estimated to take 7+ days, versus under 2 hours with the H*TMFD.

The feasibility to utilize a single CTMFD in survey mode for H*10 dose rate (μRem/h to mRem/h) measurements (tied to pre-programmed energy spectra) within 2-3 minutes was demonstrated.