Experience Monitoring for Low Level Neutron Radiation at the H-Canyon at the Savannah River Site

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Overview

• DOE contractors are required to monitor external occupational radiation exposure “of an individual likely to receive an effective dose equivalent to the whole body of 0.1 rem (0.001 sievert) or more in a year.”
Overview

• This is equivalent to 0.05 mrem/hr (0.5 μSv/hr).
• For neutrons, this can be challenging!
• Traditional surveys with shielded BF$_3$ proportional counters are difficult to conduct, particularly at low dose rates.
Overview

• A modified survey method was used:
  – unshielded He3 detector (elevated gross slow neutron counts)
  – BF$_3$ Proportional Counters in Integrate Mode.
  – Area thermoluminescent neutron dosimeters (TLNDs)
Overview

• Initial data suggested we had a problem in an office area.

• Follow-up troubleshooting and analysis definitively concluded that the neutron doses were low.
Basic Problem

• neutron dose
  • predominantly from higher energy neutrons.
  • requires a thermalizing material around the detector.
  • We are able to confidently measure dose rates as low as 1 mrem/hr with these instruments in the survey mode.
Monitoring for Slow Neutrons

- Much easier to do.
- But not necessarily proportional to dose.
Monitoring for Slow Neutrons

Quality Factor vs. neutron energy per 10CFR835

- eV
Monitoring for Slow Neutrons

- Used a $\text{He}_3$ detector with small hand-held counter.
- Very easy-to-use, but data is in cpm, not dose rate.
Monitoring for Slow Neutrons
-initial finding of high count rates

ESM readings in cpm, waist level/floor level
Monitoring for Slow Neutrons - detailed count rate in one office
The source of the neutrons

The H B-Line Facility, shown here in the left and lower portions, is adjacent to the H-Canyon Facility offices. H B-Line currently has a glove box in the room shown with a neutron dose rate up to 500 mrem/hr.
Shielded BF$_3$ proportional counters results

- Readings in Integrate Mode provided results over 0.2 mrem/hr.
- Results were inconsistent with expected variations room to room and instrument to instrument.
- Troubleshooting was exacerbated by the long count times required (up to four hours).
Shielded BF$_3$ proportional counters results

• Troubleshooting revealed that one of the monitors had a background of 0.2 mrem/hr.

• The procedure for Integrate Mode was revised to check for background reading.

• As a result, however, this method takes longer.
TLND results

• The main office of concern had a high reading (in mrem/hr), determined over 43 days of 0.18 neutron and 0.047 deep gamma.

• The adjacent office had a high reading (in mrem/hr) of 0.009 neutron and 0.002 deep gamma.
Further analysis

- In the main office of concern, the TLND was placed at a conservative location with respect to personnel exposure.
- The current occupants wore TLDs, (not TLNDs), but their gamma readings were low enough to ensure by ratio that they were not exceeding the 100 mrem/yr neutron exposure.
Further analysis

- Past office occupants sometimes wore a TLD or a TLND. Readings indicated that occupants frequently had readings less than 100 mrem/yr neutron. Other exposure was from work in radiation areas.
Area TLNDs placed in adjacent areas showed that the dose rates are variable, but we had our test TLND in place during a relatively high-reading period.
Conclusions

• Gross slow neutron counting was very helpful.
• Using the Shielded BF$_3$ proportional counters in Integrate Mode highlighted the potential trap of unfamiliar measurement techniques.
• Area TLNDs were shown to be extremely useful.
• Dosimetry History was also extremely useful.
• This monitoring history had a happy ending – case closed with no impact, rather than a potentially difficult dose reconstruction.