

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U. S. Department of Energy.

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EXPERIENCE MONITORING FOR LOW LEVEL NEUTRON RADIATION AT THE H-CANYON AT THE SAVANNAH RIVER SITE

ABSTRACT

Department of Energy 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. For a working year of 2000 hours, this translates to a dose rate of 0.05 mrem/hr (0.5 μ Sv/hr). This can be a challenging requirement for neutron exposure because traditional surveys with shielded BF₃ proportional counters are difficult to conduct, particularly at low dose rates. A modified survey method was used at the Savannah River Site to find low dose rates in excess of 0.05 mrem/hr. An unshielded He³ detector was used to find elevated gross slow neutron counts. Areas with high count rates on the unshielded He³ detector were further investigated with shielded BF₃ proportional counters and thermoluminescent neutron dosimeters were placed in the area of interest. An office area was investigated with this method. The data initially suggested that whole body neutron dose rates to office workers could be occurring at levels significantly higher than 0.1 rem (0.001 sievert). The final evaluation, however, showed that the office workers were exposed to less than 0.1 rem/yr (0.001 sievert/yr) of neutron radiation.

Background

Low levels of neutron radiation are difficult to quantify. Typically, neutron dose rates are monitored with heavy and somewhat bulky portable instruments. These instruments are insensitive when compared with dosimetry requirements. This is due to the underlying physics: neutron dose comes predominantly from higher energy neutrons and to count them 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, whereas dosimetry is required to measure a dose of 100 mrem/yr (0.05 mrem/hr average over a 2000 hour work year) (US Department of Energy, 2005). (The comparable requirement under 10CFR20 is 500 mrem/yr (0.25 mrem/hr average over a 2000 hour work year) (US Nuclear Regulatory Commission, 2005).

A recent survey campaign was initiated at the Savannah River Site to identify any areas not previously identified that could provide dose to unmonitored personnel of greater than 100 mrem/yr. In order to identify potential areas of interest, an unshielded He³ detector was used to find elevated gross slow neutron counts. Areas with high count rates on the unshielded He³ detector were to be further investigated with shielded BF₃ proportional counters and thermoluminescent neutron dosimeters. An office area was investigated with this method.

He³ detector Surveys

A special survey was conducted using a non-shielded neutron detector (FH 40 G Survey Meter with a FHZ 752 SH He3 detector, small size made by ESM Andersen Instruments GmbH). The ESM provides results in cpm which cannot be correlated to dose rates due to the energy-dependence of both neutron dose rates and the detector sensitivity. The results of this survey identified areas where further measurements should be performed.

The initial ESM Survey result for the H-Canyon Fourth Level offices is shown below:

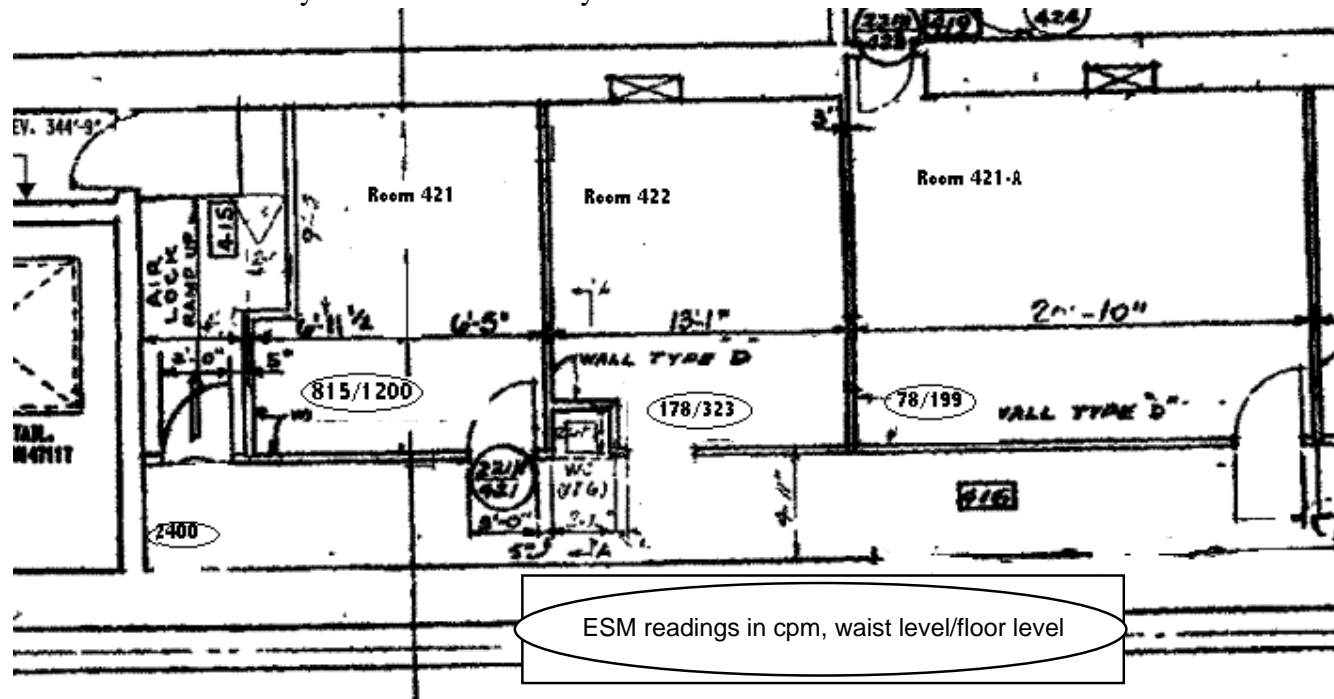


Figure 1: ESM First Survey

Source of the Exposure

The source of the exposure was determined to be room 311 in HB Line. HB Line is a separately managed facility in the same building as the offices, which are managed as part of the H Canyon facility. Surveys were taken from all other potential points of origin, but no other areas of significant neutron dose rates were found. Room 311 contains residual plutonium and fluoride of sufficient quantity to produce the levels found above it in room 421. (References 1-5)

Shielded BF₃ Proportional Counter Surveys

Follow-up surveys were taken with Eberline ASP-1 neutron survey meters. These surveys resulted in some confusion because they were performed with the meter in integrate mode, a rarely used method. In the course of performing these surveys, it was discovered that the procedure did not account for potentially significant false background rates (due to electronic noise) in the integrate mode, and one of the survey meters used was identified as having a background dose rate of nearly 0.2 mrem/hr. The results therefore, are largely difficult to interpret or clearly represent the false high background from one survey meter. Another survey meter provided a reading of 0.04 mrem/hr, which was found to have a essentially no electronic noise in the background reading. The survey procedure was corrected to consider the background from electronic noise.

Area Thermoluminescent Neutron Dosimeters Results

Thermoluminescent neutron dosimeters (TLND's) were placed in the office of concern and a nearby office from mid December to early February. The results are provided in table 1:

Table 1: Test TLND results

Room	Location in room	Reading over 43 days		mrem/hr	
		Neutron	Deep gamma	Neutron	Deep gamma
421	Southwest corner at knee height	186	48	0.18	0.047
421-A	Southwest corner at knee height	9	2	0.009	0.002

Other TLND's have been installed in nearby operating portions of the HB Line facility for years and the data is available. The closest TLND of interest is on the 410N stairwell and has been providing monthly readings since July 2002. The readings vary considerably. For the period coinciding with the test TLND data above, the readings from the 410N stairwell are at a relative maximum.

There are several possible explanations for the variation in area TLND readings: variations in the length of time the TLND's are posted, random uncertainty in the readings, and actual fluctuation in the neutron dose rates.

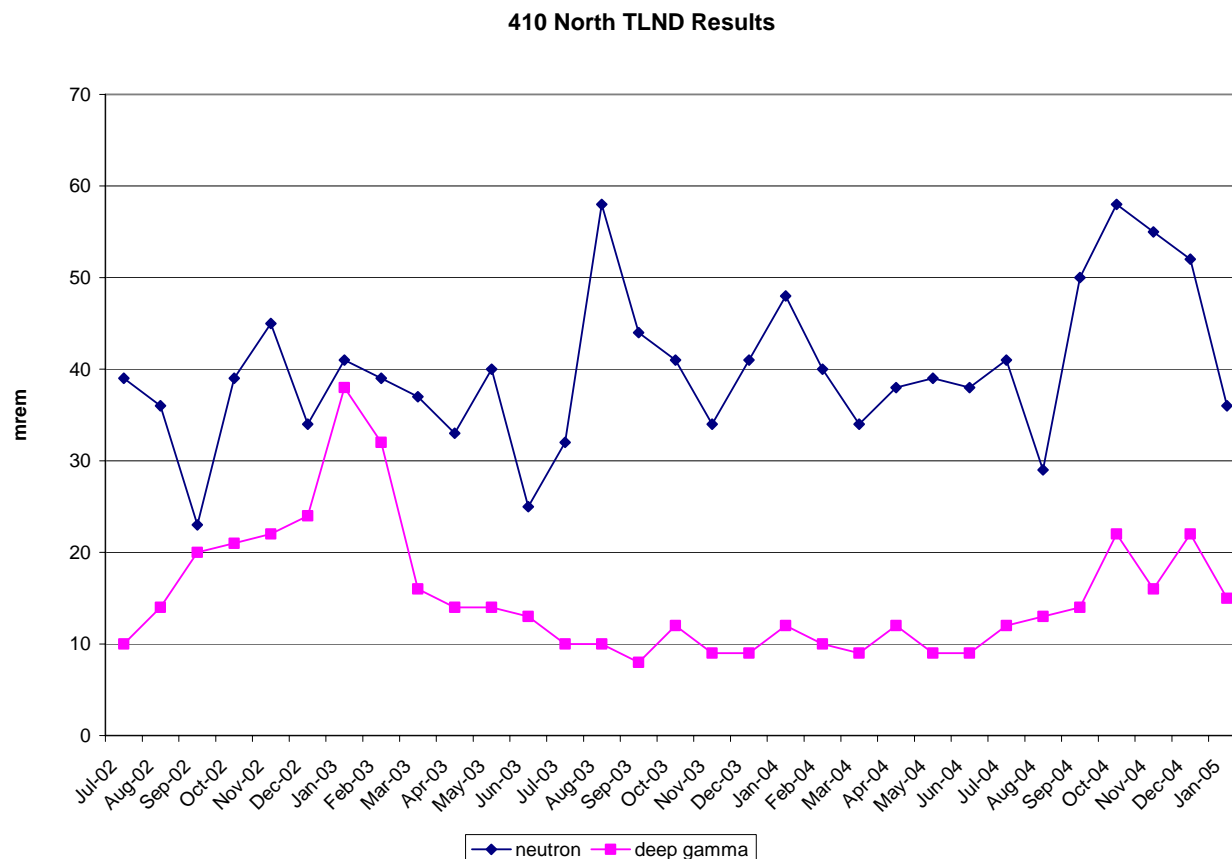


Figure 2: Area TLND 410N Stairwell

Personnel Dose Results, 2004

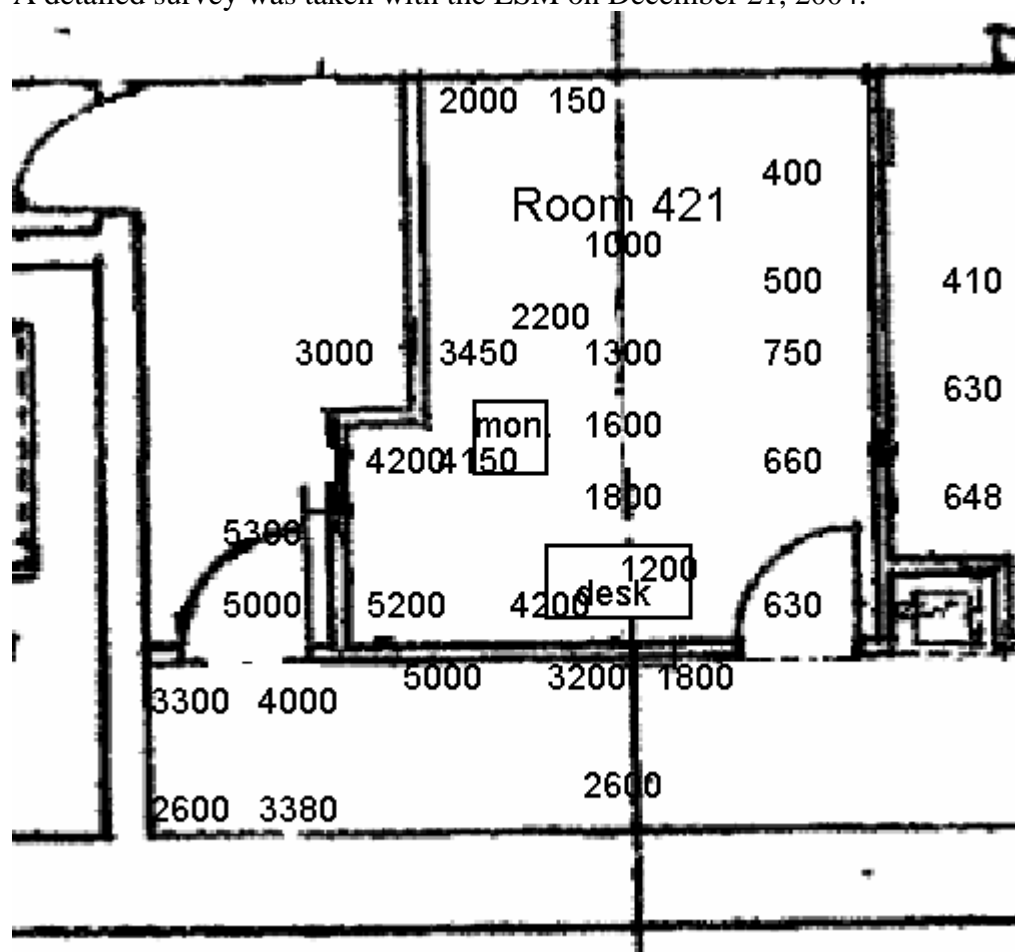
The individual with the maximum potential exposure occupies the southeast portion of the affected office but does not have office furniture in the highest dose rate area. This individual was monitored for gamma exposure during 2004 and had a total of 9 mrem. This exposure included all of his radiation work where significant neutron exposure is highly unlikely. This individual's neutron exposure can be conservatively estimated assuming that 6 mrem gamma exposure (9 minus 3 mrem attributable to a job dose recorded on electronic personal dosimetry) was obtained in the neutron field in this office. Since in the office, the neutron levels are 3.88 times the gamma levels, the potentially missed neutron dose would be only 23 mrem.

Based on this evaluation, personnel dosimetry for neutron was not required per 10CFR835.401(b)(2) and 835.402(a).

Personnel Dose Results, prior years

Dosimetry results were examined for four individuals who were identified as having occupied office 421. Dosimetry results for these individuals vary greatly. The results provide many instances that either show neutron monitoring results less than 100 mrem or gamma-only monitoring results that would have had less than 100 mrem by the ratio method used above.

A detailed survey was taken with the ESM on December 21, 2004.



Another ESM survey was taken after six inches of polyethylene shielding was added to the southeast corner of the room.

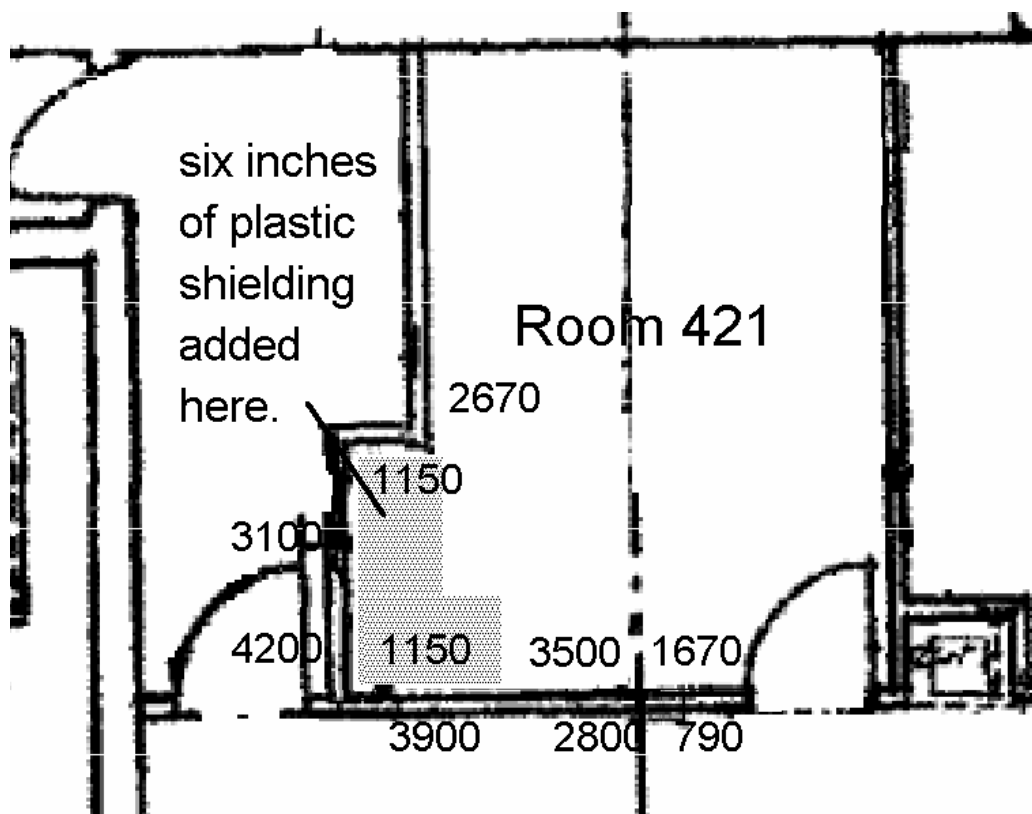


Figure 4: ESM Survey after shielding

Conclusion

Personnel dosimetry results confirm that the neutron dose rates have not exposed personnel to dose rates exceeding 100 mrem in a year. This is a reasonable result considering that the highest dose rates are in a nook of the office that has been consistently used for equipment and material storage. This nook is reported to have contained camera equipment for many years and recently has contained paper and other office material. The office is split by the section 4 to section 5 expansion joint, which entails a thick concrete girder that provides extra neutron shielding and causes the neutron flux to drop off quickly. The addition of shielding to the nook area will further ensure that the dose rates not cause any significant personnel dose.

References

- National Institute for Occupational Safety and Health (NIOSH). OCAS-IG-001, Revision 1, External Dose Reconstruction Guideline, August 2002.
- US Department of Energy. Occupational Radiation Protection, 10CFR835.401(b)(2) and 835.402(a), Revised as of January 1, 2005.
- US Nuclear Regulatory Commission. Standards for Protection Against Radiation, 10CFR20 Sec. 20.1502 and 20.1201(a), Revised as of January 1, 2005.