A THERMOLUMINESCENT ENVIRONMENTAL DOSIMETER UTILIZING $\text{CaF}_2:\text{Dy}$ ^(a)

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An environmental dosimeter (Figure 1) has been developed at Hanford to improve the long-term, low dose capabilities of our Environmental Evaluation Section. This dosimeter incorporates $\text{CaF}_2:\text{Dy}$ thermoluminescent material* with a set of photon filters to flatten the low energy overresponse of the $\text{CaF}_2:\text{Dy}$. This system will measure total exposures of 0.5 mR, referenced to photon radiation from ^{226}Ra in equilibrium with daughters (840 keV Eff) at the 95% confidence level. Energy dependence of the system over the range of 135 keV to 2 MeV was $\pm 10\%$ referenced to $^{226}\text{Ra} + \text{daughters}$ (Figure 2).

Two different environmental dosimeters have been in routine field use at Hanford--the Victoreen Stray Radiation Chamber and the Victoreen Pocket Ionization Chamber. While the Stray Radiation Chamber has proven quite successful, it requires frequent servicing because of its low dose range. The Pocket Chambers have an adequate range for the environmental program, but exhibit excessive charge leakage in the chamber and are sensitive to mechanical shock. It was decided to update the present system and include in the new dosimeter the capability of measuring large exposures. This would enable the TLD system to serve as a disaster dosimeter in the event of an inadvertent high level release of the environs.

The TLD system consists of a plastic capsule, 1/2" in diameter and 15/16" in length. Inside the capsule is a double filter consisting of 350 mg/cm² of Pb and 435 mg/cm² Ta. The filters completely surround

*Harshaw TLD-200

the three 1/8" x 1/8" x .035" TLD-200 blocks placed inside the capsule.

The blocks are secured inside the capsule between two pieces of styrofoam, which also act as a light shield to block the UV, which adversely affects the response of the TLD-200⁽¹⁾.

The TLD-200 is read out on an Eberline Model TLR-5 reader, using 0.5 liter per minute of N₂ gas as a purge. The readout cycle consists of a preheat to $95 \pm 5^\circ\text{C}$ for 10 seconds followed by the readout at $275 \pm 5^\circ\text{C}$ for 15 seconds. This readout temperature avoids the UV induced photopeak at 350°C reported by Binder, et.al.⁽¹⁾ and is used to ensure against inadvertent exposure to UV. The readout cycle does not completely erase the dose information on a TL block. As was found by others⁽²⁾, an anneal of at least 350°C for 10-15 minutes is necessary to completely erase the information. Therefore an annealing cycle of 400°C for 20 minutes was adopted for this system.

Before introduction of the 400°C anneal, we had been plagued with a shifting calibration and high TL background. After the introduction of the annealing procedure, the TL background dropped from 45 ± 10 reader counts to 8 ± 3 counts; a 1 mR dose remained constant at 55 net reader counts. The reader background with a bare planchet is 4 counts.

The dosimeters were calibrated with ^{226}Ra + daughters at the Battelle Northwest Radiological Calibration and Standards laboratory⁽³⁾. Exposures were verified with either Victoreen R-meters or a Victoreen Radocon II. The resulting calibration curve is shown in Figure 3, with the error bars indicating the scatter of the measurements. An energy dependence study was made of the system using heavily filtered x-rays with E_{eff} from 60 to

175 keV and photon radiation from ^{137}Cs , ^{226}Ra + daughters and ^{60}Co . The resulting energy dependence curve is shown in Figure 2, normalized to ^{226}Ra + daughters.

Fading studies⁽¹⁾⁽²⁾ have shown the problem to be quite complex, being a function of dose rate, time, total exposure, UV exposure and possible other factors. Fitzsimmons⁽²⁾ found about 5-10% fading with a 400 mR exposure over a 30-day period when using a similar anneal procedure as is used with this system. A fading study has been completed on this system which show that if the TLD-200 is held for 24 hours after exposure before readout, there is 7% fading between the 24 hour and four week readout.

Laboratory tests show this system to be accurate to within $\pm 10\%$ at the 95% confidence level. Precision is very good; a series of 60 dosimeters exposed at 1, 3 and 10 mR showed standard deviations of $\leq 5\%$. Field tests have shown standard deviations of $\leq \pm 8\%$. Field comparisons of the TLD with the two ionization chambers shows the TLD in good agreement with the Victoreen Stray Radiation Chamber to about $\pm 5\%$, and consistently lower results than the Pocket Chambers. This was expected because of the discharge associated with the Pocket Chambers.

The TL system is presently completing field testing in which the dosimeters are being used as both atmospheric and river monitors. As river water dosimeters, the capsules are sealed and anchored at predetermined depths in the Columbia River. The atmospheric dosimeters are mounted 1 meter above the terrain at approximately 20 locations. Both applications have yielded quite satisfactory results. A typical range of exposures in the Hanford environs would be 0.25 to 0.5 mR per day. With this exposure range, the dosimeters are left in the field from two weeks to one month.

The preliminary data reported above indicate that $\text{CaF}_2:\text{Dy}$ may be a useful low level environmental dosimeter, capable of detecting small changes in ambient exposure levels. Their small size, ruggedness and environmental resistance have extended the capabilities of the traditional environmental monitoring program at Hanford.

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References

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FIGURE 1. THE ENVIRONMENTAL DOSIMETER USING $\text{CaF}_2:\text{Dy}$

FIGURE 2. PHOTON ENERGY RESPONSES OF THE TLD200 CAPSULE

FIGURE 3. CALIBRATION OF THE TLD200 CAPSULE TO ^{226}Ra + DAUGHTERS, USING A 400°C FOR 20 MINUTES ANNEALLING CYCLE