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NEVADA TEST SITE NEUTRON DOSIMETRY-PROBLEMS/SOLUTIONS.

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Historically, neutron dosimetry at the NTS was done using NTA film and albedo LiF TLD's. In 1987 the dosimeter type was changed from the albedo TLD based system to a CR-39 track etch based system modeled after the program developed by D. Hankins at LLNL.

Routine issue and return is performed quarterly for selected personnel using bar-code readers at permanent locations. The capability exists for work site issue as-needed. Issue data are transmitted by telephone to a central computer where it is stored until the dosimeter is returned, processed and read, and the dose calculation is performed. Dose equivalent calculations are performed using LOTUS 123 and the results are printed as a hard copy record. The issue and dose information are hand-entered into the Dosimetry database. An application is currently being developed to automate this sequence.

The CR-39 is etched in chambers made of Lucite (methyl methacrylate). Hankins and Budemier found that some LLNL chambers were warping with age, affecting dosimeter results. Experience at the NTS has confirmed this. Track density per unit dose equivalent would vary from column to column in the chamber. An unsuccessful attempt was made to remedy this problem by adding a heavy aluminum bar across the chamber top and using a torque wrench to assure uniform tightening of the bolts.

A newly designed chamber has been fabricated. The KOH reservoir was partitioned into four sections each of just sufficient size to accommodate openings to wet six foils. This left walls around each section to support the assembly top. Wall penetrations allow fluid levels to equalize. More bolts were added in an attempt to assure uniform clamping pressures. These chambers are being tested.

Reading the foils is accomplished with a TV camera coupled to a microscope. The original method was to illuminate the foil from beneath, using transmitted light. An Artek bacterial colony counter is used to recognize, mark and count the tracks. Using transmitted light produced dark shadows on a bright field, and tracks could not be distinguished from surface defects. Therefore, to avoid background counts, only the best CR-39 was used.

P. Koch (REECo) found that low reflection-angle lighting from above the foils produced bright track images on a dark field enabling the colony counter to reject most surface defects.** He performed the studies and developed the equipment necessary for optimum application of this technique. The result was reduction of foil background and a decrease in the CR-39 rejection rate.

During reading, the foils were mounted individually on the microscope stage which was moved manually to allow six areas per foil to be read. To reduce the read time, an automated programmable microscope stage was constructed and implemented. The stage holds 24 foils and performs the movements necessary to count six areas per foil.

REECo has acquired the "frame grabber" hardware and software needed to digitize the TV image and use the track size distribution and dose calculation software written by S. Homann (LLNL). Use of this system will eliminate much of the manual data transfer that is currently done. The track size distribution software is expected to be useful in the further reduction of background.

As track densities rise an increasing number of tracks are nearly coincident and the ability of the colony counter to resolve and mark them for counting steadily deteriorates. A study showed that the effect was due to orientation of track pairs as well as their proximity. Calibration data was used to define a second order equation that can be used for dose calculations up to 6 rem.

An experience at the NTS indicates that dose equivalents in the range of 20 rem are measurable. A dosimeter used for environmental monitoring was exposed to a low level source for 2304 hrs at the waste storage area. The Artek counter yielded 16411 tracks/cm^2 and a linearity corrected dose equivalent of 23.85 rem. Visual counting yielded a density of 49700 tracks/cm^2 and a dose equivalent of 20.29 rem. A dosimeter exposed for 96 hr in the same neutron field produced a density of 2800 tracks/cm^2 and a linearity corrected dose equivalent of 0.96 rem. This equates to a dose equivalent of 23.02 rem in 2304 hr.

A study was conducted to document the neutron dosimeter background at the NTS. Information used for the study was compiled from records of background foils in each batch. The average background at Mercury is 7.5 mrem/yr. As is evident from the graph, the data are highly variable from sheet to sheet. There is some question whether this background is from neutrons, physical defects in the plastic, or alpha tracks originating from Rn daughter contamination acquired during some stage of manufacturing.

Calibration is performed at the Dosimetry Calibration Facility on the NTS. The dosimeters are mounted on a phantom, and the source is transferred to the outdoor range manually. This system does not conform to the ALARA concept, although the doses received are low. A new calibration range has been designed for retrofit into the existing building.

Foil etch quality control accounts for a large fraction of the program cost. At least 6 of each 24-foil batch are for QC. An additional 2 or 3 foils per batch are used in the blind audit program. Almost 50 % of the dosimeters processed are for quality control. As is evident from the background dosimeter results, this amount of QC is necessary.

After adopting the system from LLNL, REECo personnel have made some contributions to progress in the field, but there continue to be some unsolved problems. A major one is evidenced by marked variations in calibration foil track densities. This may be caused by an unequal power application to all foils in the same chamber.

Though the system is very labor intensive with expensive QC requirements, it is attractive for NTS operations where exposures, of small magnitude to a small number of people, come mostly from high energy neutrons from PuBe or AmBe sources.

To use CR-39 in a facility where a large number of personnel are monitored, all aspects of the program need to be automated. Steps have been taken in the issue/return, reading, and dose processing areas to automate processing. These consist of developing computer applications to control equipment, and record and manipulate the information collected during these operations. Most of these are currently in progress and in varying stages of completion.

Dosimeter assembly and disassembly, foil preparation and chamber loading and unloading are still manual operations. There appears to be little hope for anything but invention of mechanical aids that produce small increments in efficiency.

The number of QC dosimeters required to maintain the reliability of the system is high, and must remain so until etch chambers of improved reliability can be made.

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** P. N. Koch;L. S. Sygitowicz An Improved Technique for Reading CR-39 Track Etch Neutron Dosimeters. Health Phys. 58, Sup. 1:S64;1991.