DOSIMETRIC SURVEY IN THE PELLETRON AND LINEAR ACCELERATORS

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ABSTRACT

Several dosimeters, both thermoluminescent and photographic, were distributed to measure exposures in the vicinity of the vertical 22 MeV electrostatic accelerator (Pelletron) and the 45 MeV traveling-wave electron accelerator (Linear Accelerator). The results corroborate initial measurements with survey meters. The dosimeter arrays give the gamma-ray exposures, and indicate the effective gamma-ray energy and the thermal neutron fluence.

INTRODUCTION

To determine the inhabitability of areas near particle accelerators, survey meters are an obvious first choice since clearly dangerous areas must be located at once. A follow-up with solid dosimeters, read after instead of during exposure, has several advantages: The dosimeter is exposed over a variety of operating conditions; energy dependence can be made small, or effective energy can be indicated; low chronic exposures can be determined with good accuracy; and clearly uninhabitable areas can be tested without risk to the operator.

Herein we report on such a follow-up survey in the vertical 22 MeV electrostatic accelerator (Pelletron) and in the 45 MeV travelling-wave electron accelerator (Linear Accelerator, to be upgraded to 70 MeV), both located at the Physics Institute, University of São Paulo.

The thermoluminescent (TL) dosimeters employed were ^{6}LiF (TLD-600)*, normal LiF (TLD-100)*, ^{7}LiF (TLD-700)*, and CaF_2:Dy (TLD-200)* all in powder and extruded ribbon form, except ^{7}LiF (powder only) and CaF_2:Dy (ribbon only). The properties of these dosimeters are extensively discussed in the literature.[1-3] Important points are: Response in LiF varies only slightly with gamma-ray energy below about 100 KeV; response in CaF_2:Dy changes considerably with gamma energy below about 100 KeV; and ^{6}LiF is sensitive to thermal neutrons due to the (n, α) reaction in ^{6}Li.

These dosimeters were usually read on a Harshaw Model 2000 reader set to maximum sensitivity; that is, using the highest possible voltage on the photomultiplier consistent with nearly complete supression of the dark current. Under these conditions, the LiF ribbons (3.18 x 3.18 x 0.89 mm) could detect 2 mR on a peak height basis when registering the glow curve. The CaF_2:Dy ribbons were in excess of ten times more sensitive. In both cases high residual TL (i.e. non-radiation induced TL) rendered the powdered samples inferior. The powder is also more difficult to handle.

For the survey the dosimeters were enclosed in plastic and taped to a 1mm thick Al plate. This plate was normally positioned in front of the dosimeters along the expected radiation direction.

Film dosimeters in their normal plastic cases were clipped alongside the Al plate[4].

PELLETRON

The Pelletron accelerator produces a beam of positive particles, beginning with negative ions in the injector (top tank, Fig.1) then passing these through the tandem accelerator (main tank, Fig.1) wherein electrons are stripped from the ions to produce positive particles. The beam is bent magnetically at the bottom of the building to enter the experimental area (left, Fig. 1). Alternately, the negative ions may originate in ion sources situated on the eighth floor between the injector and tandem machines.

Dosimeters placed in the injector, tandem, and bending magnet areas confirmed that these regions are not inhabitable during operation. Typical exposures were in the range of 0.9, 2 and 6 R respectively for the three after about 15 hours of machine operation.

More important is the eighth floor since personnel might wish to manipulate auxiliary controls or to adjust the ion sources during operation. Such activities should be kept to a minimum, however, since about 15 hours of operation gave exposures between 0.1 and 1R depending on location. Also of interest is the existence of hot spots in this room which do not follow the cylindrical symmetry of the accelerator.

In other areas, including the access stairwell and the control room (not shown in Fig. 1), exposures were not significantly above the normal background.

Comparison among the several dosimeters indicates that the effective gamma energies are above 100 KeV, and that thermal neutrons are virtually non-existent. (Neutron might be important, however, if the final beam were other than the protons present for these tests.) In other words, all species of dosimeter indicated the same exposure in each location. The film and TL dosimeters agree generally, but the film is less sensitive.

LINEAR ACCELERATOR

This horizontal machine is located below ground and directs its beam through bending and analysing magnets into the experimental area (bottom, Fig. 2). On the ground floor above, one finds the control room, away from the accelerator, and more directly above the device, there is a storage and equipment area (top, Fig.2).

Dosimeters in the storage area confirm that it is uninhabitable during operation. For example, 20 hours of test operation gave up to several R directly above the accelerator. These exposures decrease as one leaves the vicinity of the tube and approaches the control room wall so that just inside the control room the exposure is down to 40-150 mR for the same 20 hours of operation. Along the control panel (rectangular box, Fig.2), the exposure varied from 30-70 mR, while along the back wall of the room the level was down to 20-50mR (except adjoining the experimental room-140 mR). The exposures tend to increase in the direction of the experimental area. Since the 20 hours of operation were spread over more than a month, the control area might be described as marginally inhabitable. This situation should improve as the present temporary shield is replaced by the permanent one now under construction.

Comparison among the dosimeters indicates that the effective gamma energies are above 100 KeV (i.e., normal LiF,

CaF_2:Dy, and film give essentially identical readings). A thermal neutron flux is detectable, however, giving doses about 70 times less than the gammas. This estimate assumes that ^{6}LiF produces a reading equivalent to about 35 R of gammas for every rem of thermal neutrons [5]. (The LiF dosimeters consistently read about 1.5 times higher than the other dosimeters). Although these thermal neutron doses are not themselves important, they indicate the presence of fast neutrons because nuclear reactions in the accelerator are the only source of neutrons. In fact the thermal neutron fluences increase with distance from the accelerator, presumably due to increasing thermalization of fast neutrons. These fast neutrons constitute an unknown and potentially dangerous factor.

FOOTNOTES

*Trade names of the Harshaw Chemical Co.

[1] J.R. Cameron, N. Suntharalingam and G.N. Kenny, Thermoluminescent Dosimetry, The University of Wisconsin Press (Madison 1965)

[2] Third International Conference on Luminescence Dosimetry, Risø, Denmark (1971)

[3] W. Binder and J.R. Cameron, Health Physics 17, 613 (1969)

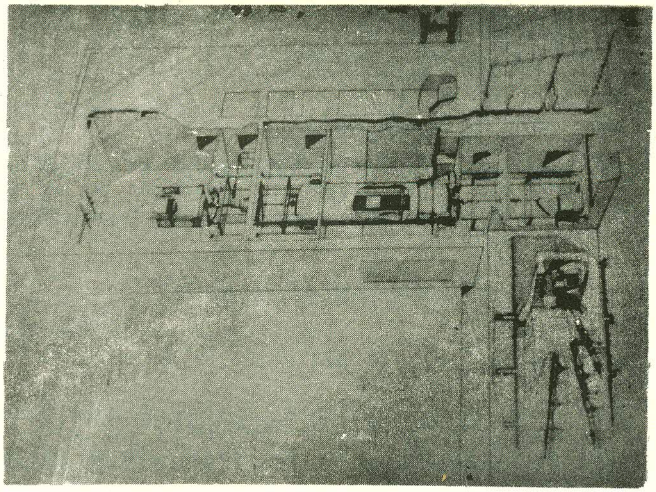
[4] For a description of the film see, Sudernaique F.de Deus and Shigueo Watanabe, these Proceedings.

[5] J.R. Cameron et al., Health Physics 10, 25 (1964)

FIGURES CAPTIONS

Fig. 1 - The Pelletron Accelerator

Fig. 2 - The Linear Accelerator. The two plans represent different levels of the same building. The right hand corners coincide one above the other in the structure.



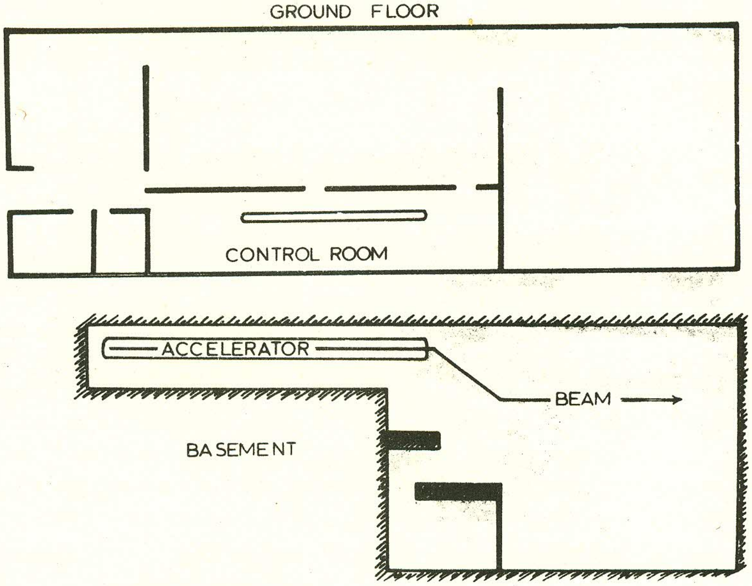


Fig. 1 and 2

QUESTION - Francisco Contreras Morales

Did people enter the high exposure areas in the rooms beside the control room before your survey was made ?

ANSWER - M.R. Mayhugh

I'certain that they did not, because our inquires were preceeded by measurements with a survey meter, as one would expect.

QUESTION - G. Nowotny

I would like to know whether or not INTERLOKS exist in the access passages to this accelerator, and if so how they function.

ANSWER -M.R. Mayhugh

I'm not certain, but I believe the interlock is based on a single key system: the key is necessary to enter the accelerator and also necessary on the control panel for start-up. Start-up is preceded by the sounding of a siren.