ANDREA, a compact neutron dosimeter

A. Sokolov[1], *G. Fehrenbacher*[1], *E.Kozlova*[1], *and T.Radon*[1]
[1]GSI, Darmstadt, Germany

Accelerator facilities are widely used for research and medical treatments, still they are sources of radiation potentially harmful for the surrounding environment and people. For the radiation survey the dose rates inside the accelerator tunnels as well as outside the shielding must be monitored. The highest contribution to the dose rate especially in case of high energy and heavy ion acceleration comes from neutron radiation, meaning that the neutron dose detection should be of highest priority. At GSI the approved technique for this purpose implies the GSI ball [1], appropriate for the ambient dose equivalent measurements for neutrons from 10 meV up to 100 GeV energies. Nevertheless this passive dosimeter is quite heavy and large with a diameter of D=31cm. In order to decrease the dimensions, weight and production costs, as well as to improve the characteristics of the dosimeter this work was done.

The main principle of the dosimeter to provide the readout values close to the ambient dose equivalent [2] is to use the moderating outer layer, typically – Polyethylene (PE) or Polypropylene (PP) for lower neutron energies and to use a lead layer in order to improve the response of the detector for higher energies, at which the spallation in form of neutrons ejection takes place. Next to the lead layer there is an additional small moderating layer (PP/PE) with a TLD-card, TLD=ThermoLuminescence Dosimeter.

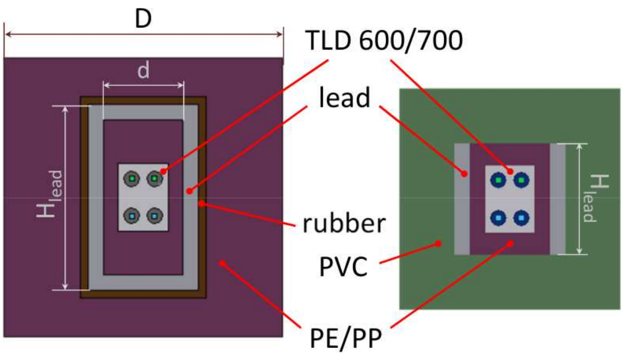

Figure 1: Dosimeter of type 3 (left) and type 5 (right).

Numerous simulations were performed using the FLUKA code [3] in order to obtain a simple and compact design of the dosimeter. First of all the dosimeter was chosen in a form of a cylinder (Fig.1, left), which still had the height of 31cm, but the diameter is only 20 cm. The smaller diameter for this type 1 dosimeter, is possible due to the introduction of an additional rubber layer with a small amount of boron, 5 % of the total mass. One can find the read-out signal in Fig.2, where it is seen that the response function of the dosimeter is close to the desired fluence-to-dose values H*(10) presented in [2]. To improve the response in the higher energy region, especially around 10 MeV, the outer dimensions were kept, while the inner cylinder was increased in diameter providing better moderation in the region of interest. The result is the type 2 detector, see Fig.2. Decreasing the outer diameter significantly influences the response in the low energy region, leading to an overestimation of the dose. This can still be managed changing the concentration of boron in the rubber layer. For the type 3 detector, with a diameter of 16 cm the boron portion was increased to 10 %. The improved response function can be seen in Fig.2.

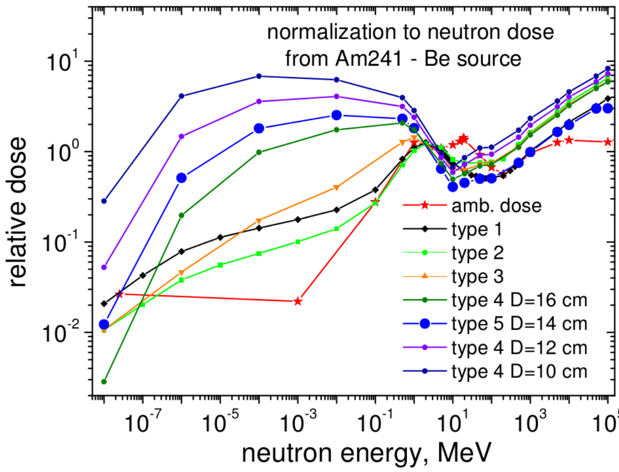

Figure 2: Ambient dose and comparison of response functions for different types of dosimeter.

Still the presence of the rubber layer makes the design more complicated and construction costs higher. To get rid of the rubber another material was chosen for the outer layer - Polyvinylchloride (PVC), which is a cheap and almost non-flammable plastic. In Fig.2 one can see the response functions for the dosimeter of type 4 with different outer PVC diameters from 16 cm down to 10 cm. Usage of the PVC as a moderating material together with a bigger diameter of the inner cylinder provides a possibility to reduce the height of the lead cylinder and get rid of its bottom and top caps, making the design simpler (Fig.1, right), the dosimeter is distinctly lighter and the over-response in the high energy region smaller (Fig.2, type 5). So finally in comparison to the GSI ball the weight is reduced from 19 kg to 4.5 kg and the size from 31 cm to 14 cm, both dosimeters can be seen in Fig.3. The compact design reduces the

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Figure 3: Neutron Dosimeters: ANDREA, type 5 (left) and GSI ball (right).

overall absorption and increases the total signal. Still a slight under-response in the vicinity of 10 MeV and over-response in the low energy region remain and are the issues for further improvements. The name of this type 5 dosimeter is ANDREA=A Neutron DosemeteR for Efficient Area monitoring.

References

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