CONSIDERATIONS ON THE DOSIMETRY FOR HIGH-ALTITUDE FLIGHTS USING THE METHODS DEVELOPED IN INSTITUTE OF ATOMIC ENERGY

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According to the recommendations of European Commission [1] and the new project of Polish Atomic Law it will be necessary to assess the exposure of air crew to cosmic radiation.

Doses from cosmic radiation vary strongly with altitude and also with latitude and with the phase of solar cycle. Now the substantial body of knowledge facilitates the assessment of likely exposures. For air crew, whose annual dose falls in the range 1-6 mSv, there should be individual estimates of dose. When annual dose is likely to exceed 6 mSv, record keeping is recommended with appropriate medical surveillance. Aircraft capable of operating at altitudes greater than 15 km should carry an active radiation monitor.

The present state of knowledge, the needs and ways of cosmic radiation monitoring have been presented and discussed on Symposium organised in December 1999 in Kraków by Institute of Nuclear Physics and Polish Society of Medical Physics.

The complexity of dosimetry for space and high-altitude flights is still a challenging task. The methods considered in IAE include the use of the recombination chamber and the Makrofol track detectors (elaborated in Forschungszentrum Karlsruhe).

The recombination chambers are particularly useful detectors for the dosimetry of complex radiation fields [2]. They were already used for indication of LET spectra during stratospheric flights [3] and, more recently, the chamber of REM-2 type was examined, with very good results, in CERN, in standard fields simulating radiation fields at flight altitudes of 10 - 14 km [4].

The signal of the REM-2 chamber working in saturation mode is proportional to ambient dose $D_{\ast}(10)$, working in differential mode - to ambient dose equivalent $H_{\ast}(10)$.

The relatively low sensitivity, especially in differential mode, is a drawback of the chamber. The problem has been partly solved by use of self-contained measuring system [5], consisting of a recombination chamber and two or three capacitors (Figure 1). The capacitors serve as sources of polarising voltage and also as elements integrating the chamber current.

A simple procedure was introduced just before the readout to compensate the influence of any changes in polarising voltage and temperature during the exposure.

The self-contained system with the recombination chamber of REM-2 type has been investigated both in laboratory and in field conditions. It was checked also in above mentioned CERN reference fields, both in saturation and in differential mode. It was possible to measure ambient dose of order of fraction of µGy and ambient dose equivalent of several µSv, providing the time of charge collection was less than 24 hours. At longer periods there was considerable uncertainty of the reading, in the case of differential mode too high to recommend that mode for in-flight dosimetry.

The uncertainties arising at long time exposure can be explained by the phenomenon of dielectric absorption in the capacitors of self-contained system. The dielectric absorption may have rather long relaxation time constant - in our case of several days. Internal capacities $C_a$ introduced in Fig.1 as responsible for the dielectric absorption, facilitate to understand the influence of this phenomenon on the reading of the system in long time. The uncertainty introduced by the dielectric absorption is negligible in saturation mode due to much higher sensitivity to radiation. At this mode the sensitivity, accuracy and reproducibility of measurements are sufficient to determine the ambient dose $D_{\ast}(10)$, collected during one or several flights and read out after about one week. To determine the ambient dose equivalent $H_{\ast}(10)$ the additional information is needed, concerning the quality factor of radiation and/or the contribution of neutrons and other high LET particles to the absorbed dose.

![Fig. 1. Self-contained measuring system. Capacities $C_a$ represent the dielectric absorption in capacitors.](image)

High energy neutron component of cosmic radiation can be measured with track detectors, [6]. As a result of extensive research, the foils of polycarbonate Makrofol DE 475 have been chosen as the detectors.
The optimised, two-step electrochemical etching was applied to reveal the tracks. The energy dependence of the neutron response of Makrofol has been examined with monoenergetic neutrons, with isotope source neutrons, and in high energy neutron fields at PSI and CERN. The results are shown in Figure 2 and in Table 1.

Due to the low background track density and the sufficient sensitivity for the cosmic neutron spectrum, the Makrofol DE detectors offer the possibility to measure the neutron component of the natural background radiation. They are suitable to monitor the long-term neutron exposures at typical airflight altitudes, for representative individuals and routes, with a lower detection limit of 0.2 mSv per year. Makrofol detectors can also record heavy charged particles, starting from alpha particles.

The self-contained measuring system with recombination chamber working in saturation mode could give, together with Makrofol foils, a system of detectors for the determination of ambient dose equivalent during high altitude flights.

REFERENCES


THE NEUTRON RESPONSE OF STUDSVIK - ALNOR 2202D REMMETER.
AN ATTEMPT OF OVERREADING ESTIMATION

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In neutron remmeter 2202D Studsvik - Alnor the thermal neutron detector, BF₃ proportional counter, is placed inside thick, cylindrical neutron moderator with absorbing layer, to provide reasonably “flat” dose equivalent response of the instrument relating to neutron energy. The fluence response of 2202D was examined with monoenergetic neutrons and in the fields of isotope sources [1], then recalculated into response to ambient neutron dose equivalent H*(10)ₙ [2] (Fig. 1).

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