

Progress Report of the Department 'Radiation Protection Dosimetry'

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Secondary standard chamber for the ambient dose equivalent $H^*(10)$

A secondary standard ionisation chamber for photon radiation for measuring an ionisation current which is directly proportional to the conventionally true value of the ambient dose equivalent, $H^*(10)$, was optimized at the PTB. The original chamber (type: HS01, geometry: sphere with a diameter of 1400 mm, active volume: 1000 cm³) was developed in 1992 in the Austrian Research Centers Seibersdorf by Duftschmid et al. and is used successfully worldwide by dosimetry laboratories. The response of this chamber with respect to $H^*(10)$ for photon energies from 40 keV to 1250 keV is nearly constant. For lower photon energies the response is strongly energy-dependent and doesn't fulfil the requirements concerning the quality of a secondary standard given in ISO 4037-2, i.e. for energies for which the determination of the conventionally true value of $H^*(10)$ is very difficult. To get a secondary standard chamber for $H^*(10)$ with a nearly constant response for high as well as low photon energies, this chamber was optimized. The original sphere chamber was jacketed with a shell with a 5.7-mm-wall thickness and made completely with Makrolon[®] (polycarbonate: (C₁₆H₁₄O₃)_n, density: 1.2 g/cm³). The response of this optimized chamber changes in the energy range from about 12 keV to 1250 keV by only 10%.

Chamber calibration can be performed by the PTB using the radiation qualities according to ISO 4037-1.

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Figure: Optimized secondary standard chamber for the ambient dose equivalent $H^*(10)$ for photon radiation



Figure: Sketch of the optimized secondary standard chamber for $H^*(10)$

X reference radiation qualities produced with tube voltages above 300 kV for the calibration and testing of dosimeters

In the international standard ISO 4037-1, only X reference radiation qualities produced with tube voltages of up to 300 kV and with mean photon energies of lower than 250 keV are defined. Higher energy reference photon fields are given with a mean energy only from 662 keV (S-Cs) upwards. To close this energy gap, four new X-radiation qualities, produced with tube voltages of 350 kV and 400 kV, were realized at the PTB. The filtration of two of these qualities – called N-350 and N-400 – was chosen in such a way that they agree with the specifications of the narrow-spectrum series (N-series) defined in ISO 4037-1. The other qualities which have been created – called H-350 and H-400 – can be assigned to the high air-kerma rate series (H-series). The fluence spectra of these qualities were measured by X-ray spectrometry. The values of 23 characteristic parameters (mean photon energy, first and second half-value layer, conversion coefficients for the radiation protection quantities $H^*(10)$, $H'(0,07,\bar{\rho})$, $H_p(10)$ and $H_p(0,07)$, etc.) were determined and compared with the ISO specifications for X-ray reference fields.

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EUROMET supplementary comparison of the absorbed dose rate in tissue for beta radiation

In 2004, the EUROMET comparison No. 739 (KCDB: EUROMET.R(I)-S2) for the unit of the absorbed dose rate in 0.07 mm tissue depth for beta radiation was started. In

this comparison, radiation protection qualities realised by beta radiation sources of the participants are used: Sr-90/Y-90, Kr-85, Tl-204, and Pm-147.

A flat ionisation chamber is used as the transfer instrument. Together with this chamber, a complete electronic measurement system is circulated, see Figure. The aim of this comparison is to compare the calibration factors of the transfer instrument obtained by each participant.

Eight laboratories registered for the comparison, currently the last measurements are performed. The laboratories are: LNE-LNHB (FR), ENEA (IT), STUK (FI), PTB (DE), VNIIM (RU), NIST (US), NRC (CA); and NMIJ (JP). The results will be published soon after the completion of the measurements in Metrologia.



Figure: Transfer chamber and electronic measurement device

Dosimetry in the natural environment

The Physikalisch-Technische Bundesanstalt (PTB) has a unique combination of reference measuring sites for the dosimetry of natural environmental radiation (see progress report CCRI(I)/05-06). Two intercomparisons with different main focuses have been performed on these sites:

I. Third EURADOS intercomparison of early warning network systems

As a consequence of the Chernobyl accident early warning systems have been installed in each EU member state to detect nuclear accidents. The Working Group on Environmental Monitoring (WG 3) of the European Radiation Dosimetry Group (EURADOS) carried out a 3rd international comparison in 2006 to test dosimeters of such early warning systems, which didn't take part in the two previous ones. The only measuring quantity used in this comparison was the ambient dose equivalent rate, $\dot{H}^*(10)$. The aim was to verify if the measuring results of the dosimeters and the early warning systems, respectively, are in agreement within given limits. Teams from seven European countries participate. The intercomparison comprised investigations on the energy and dose rate dependence of the dosimeter response on gamma

radiation (^{137}Cs and ^{60}Co) and cosmic radiation. The sensitivity of the dosimeter systems to small dose rate variations, similar to that caused by passing a radioactive cloud, was studied under realistic free-field conditions by using a new free-field gamma ray irradiation facility. The comparison shows among others that some of the tested dosimeters included in early warning systems have not the capability to detect small changes of the dose rate. A publication is under work.

II. AKD-PTB intercomparison of passive $H^*(10)$ dosimeters

The intercomparison takes place between 10/2005 and 10/2007 and serves to investigate the long-term behaviour of passive $H^*(10)$ dosimeters. The intercomparison is based on an agreement concluded between the *Fachverband für Strahlenschutz e.V.* (German 'Association for Radiation Protection) for its "Dosimetry" working group (AKD) and PTB. The 10 participants come from Germany, Switzerland and Austria. During the first two half-year measuring periods more than 320 dosimeters were installed at the three different PTB measuring sites for the dosimetry of natural environmental radiation. About 110 dosimeters were additionally irradiated at PTB gamma facility. A first evaluation of the photon dosimeters shows that the mean dose given by a dosimeter type of one participant agrees with the other ones within 30% for pure environmental irradiation. In the case of additional gamma and pure cosmic irradiation, the differences between the mean dose values are nearly 50%. A complete evaluation will be performed after the completion of this comparison in autumn 2007.