EVIDOS: INDIVIDUAL DOSIMETRY IN MIXED NEUTRON AND PHOTON RADIATION FIELDS

Background

The EVIDOS project (partly funded by the European Commission RTD Programme: Nuclear Energy, Euratom Framework Programme V, 1998-2002, Contract No FIKR-CT-2001-00175) aimed at improving individual monitoring in mixed neutron-photon radiation fields by evaluating the performance of routine and novel personal dosimeters for mixed radiation, and by giving guidelines for deriving sufficiently accurate values of personal dose equivalent from the readings of area survey instruments and dosimeters. This project ran over a period from April 2002 till December 2005 and involved the collaboration of seven European institutes: PTB, IRSN, HPA-RPD, DIMNP, PSI, SSI and SCK•CEN.

Objectives

The main objective was to evaluate different methods for individual dosimetry in mixed neutron-photon work-places in nuclear industry. This implied a determination of the capabilities and limitations of personal dosimeters and the establishment of methods to enable sufficiently accurate values of personal dose equivalent from spectrometers, area survey instruments and routine personal dosimeters. Also novel electronic personal dosimeters were investigated. To this end spectrometric and dosimetric investigations in selected representative workplaces in nuclear industry where workers can receive significant neutron doses were performed. The following tasks were foreseen:

- determination of the energy and direction distribution of the neutron fluence;
- derivation of the (conventionally true) values of radiation protection quantities;
- determination of the readings of routine and innovative personal dosimeters and of area monitors;
- comparison between dosimeter readings and values of the radiation protection quantities.

Principal results

The different nuclear industries visited included a fuel element factory (BELGONUCLEAIRE, Dessel Belgium), a research reactor (Venus at SCK•CEN, Mol Belgium), a boiling water reactor (BWR) (Kernkraftwerk Krümmel Germany), a pressure water reactor (PWR) (Statens Vattenfall, Ringhals Sweden) and a fuel processing plant (BNFL, Sellafield United Kingdom). Before the campaigns, the responses of the instruments were investigated in neutron reference fields at Cadarache (France). Measurements were carried out at these different environments permitting a thorough testing of the dosimeters since they differ widely in terms of dose rates, neutron/photon relative intensity, energy distributions and also temperature, pressure, humidity, acoustic noise, vibration, electromagnetic fields, etc.

All together about 500 measured values were collected at the nuclear sites.

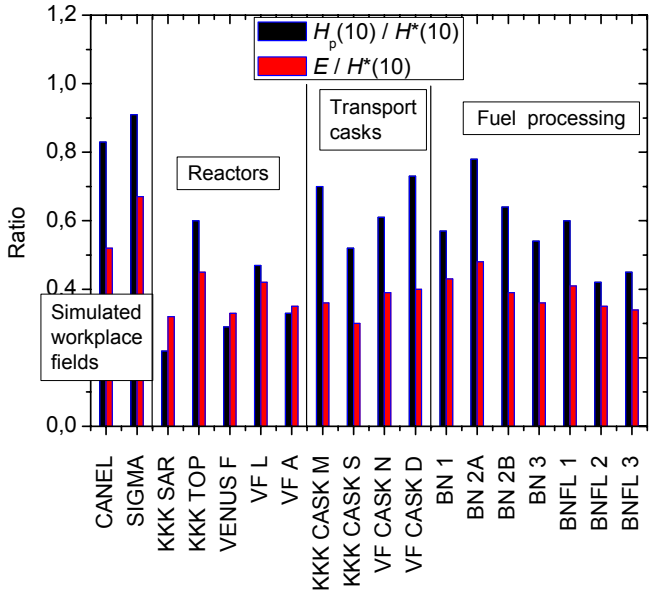
Because no current dosimeter can provide correct results in all neutron fields, reference values were derived from spectrometry (with respect to energy and direction of the radiation) and fluence-to-dose equivalent conversion coefficients. We primarily performed reference field spectrometry with a Bonner-sphere system. Measurements of the double-differential (energy and direction) neutron fluence were performed with novel instruments based on superheated drop detectors and Si-diodes. Values of ambient dose equivalent H*(10) and personal dose equivalent $H_p(10)$ for the main direction of incidence were derived by multiplying the fluence distributions by the corresponding fluence-to-dose conversion coefficients. In every workplace field, all available personal neutron dosimeters were exposed. Six commercial types of active neutron dosimeters and two pre-commercial types were used. One novel reference method for $H_p(10)$, and two novel area monitors were tested as well. Also the performance of conventional area monitors for neutrons and photons as well as passive individual dosimeters for routine monitoring were examined.

Characteristics of measurement devices used

Name of device	Short description	Commercial (c) or prototype (p)
BAE SYSTEMS	Novel area monitor for H*(10) and $H_p(10,\alpha)$ measurements	**p**
Berthold LB 6411	Moderator type area monitor	**c**
Harwell N91	Moderator type area monitor	**c**
Sievert Instrument	Low pressure proportional counters (one of tissue-equivalent plastic and one of graphite) evaluated according to the variance/covariance technique	**p**
Studsvik 2200's	Moderator type area monitor	**c**
Wendi-2	Moderator type area monitor with Tungsten loaded moderator	**c**
Aloka PDM-313	Electronic neutron dosimeter with 1 silicon detector	**c**
BTI-PND	Fast neutron bubble detector	**c**
DISN 1,25 % (2 mm)	Differential reading of two ionization chambers which are based on direct ion storage	**p**
DOS 2002	Electronic photon/neutron dosimeter with 1 silicon detector	**p**
HpSLAB	Superheated drop detector inside a slab phantom	**p**
PADC (CR-39)	Track etch detector (chemical + electrochemical etching)	**p**
PND + BDT	Combination of fast and thermal neutron bubble detector	**c**
Saphydose-n	Electronic neutron dosimeter using a segmented silicon diode	**c**
Siemens EPD N	Electronic photon/thermal neutron dosimeter with 3 silicon detectors	**c**
Siemens EPD N2	Electronic photon/thermal neutron dosimeter with 3 silicon detectors	**c**

All results are published in the final report.

An example:
In the figure, the values $H_p(10)$ and the effective dose E are given with respect to $H^*(10)$ for the FRONT direction. E is derived by folding the fluences from all directions with corresponding conversion coefficients. A conservative estimate of the uncertainty of $H_p(10)/ H^*(10)$ is 30% in this case.



Ratio of dose values for different workplace fields.

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Main reference

H. Schuhmacher, D. Bartlett, T. Bolognese-Milsztajn, M. Boschung, M. Coeck, G. Curzio, F. d'Errico, A. Fiechtner, J.-E. Kyllönen, V. Lacoste, L. Lindborg, M. Luszik-Bhadra, M. Reginatto, R. Tanner, F. Vanhavere, *Evaluation of Individual dosimetry in Mixed Neutron and Photon Radiation Fields*, Neutronenphysik, PTB N-49, Braunschweig 2006.