EUROPEAN RESEARCH INTO THE MEASUREMENT OF EXTERNAL ENVIRONMENTAL RADIATION DOSES

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INTRODUCTION

In a Commission of the European Communities (CEC) research programme spanning the past 10 years all aspects of external environmental radiation dose measurements have been thoroughly investigated (1,2). The aim of this work was to harmonize environmental radiation dose measurements within different countries. The initial studies involved research into practical calibration techniques and this led to the establishment of two unique calibration facilities. One facility developed by the Physikalisch Technische Bundesanstalt (PTB), Braunschweig, Germany in the Asse salt mine at a depth of 970 m where there is an extremely low level of environmental radiation (3). The other calibration facility is the Risø National Terrestrial Radiation Measurement Station (4) where reference measurements of a well determined natural environmental photon spectrum can be made. At Risø a cosmic measurement station has also been established at a wooden pier extending into the Roskilde Fjord, this station is used for the determination of a detector's response to cosmic radiation.

This paper describes the calibration techniques that have been investigated and the intercomparisons that have been performed. The relevance of this research programme was demonstrated by an intercomparison of external photon dose rate measurements by several detectors in the vicinity of a nuclear power station.

CALIBRATION AND TYPE TESTING

Many commercial dose rate instruments, electronic dosemeters and most thermoluminescence dosemeters (TLDs) were calibrated and radiation type tested. These tests included the determination of the inherent responses of the detectors using the Asse facility, namely the contribution to the readings from the active and passive detectors from internal radioactive contamination or from electronic noise.

The energy responses of all the detectors were measured over the photon energy range from 60 keV to 6 MeV.

The cosmic responses of the detectors were evaluated from measurements made on board boats in the North Sea and in the Roskilde Fjord and these results were then compared with measurements made at the Risø cosmic field station.

Free-field and shadow-shield calibration techniques were intensively studied at Risø and several intercalibration experiments using these techniques were carried out among the participating States. Monte Carlo (MC) calculations using the MCNP (Monte Carlo Neutron Photon) code were used to determine the air kerma rates produced by scattered photons from ^{137}Cs, ^{60}Co and ^{226}Ra sources as a result of surrounding media in different free-field and shadow-shield calibration geometries (6).

INTERCOMPARISONS

a) The assessment of external photon dose rates in the vicinity of nuclear power stations.

In 1991 experiments were carried out to investigate the responses of instruments to additional exposures above normal environmental levels. Four environmental dose rate instruments having different detectors, a high pressure ionization chamber, a Geiger-Müller counter, a proportional counter, and a scintillation counter, were used to make continuous measurements over a four month period of the air kerma rate at a location close to the Hinkley Point Nuclear Power Plant in the UK. Three types of TL dosemeters normally used for monitoring environmental radiation were also used to compare the responses of solid state passive dosemeters with those of the active dose rate meters.

The results clearly demonstrated that accurate estimations os doses in the environment arising from a nuclear facility can only be obtained if continuous measurements are made and if the responses of the detectors used to the different radiation components at that location are accurately evaluated. By correcting the measured air kerma values by the accurately determined detector responses the standard deviation, expressed as a percentage of the

mean value of the total air kerma for the instruments and TLDs was reduced from 20% to 5% (5).

b) An international comparison of active and passive detectors used for environmental radiation measurements.

During 1994 an international intercalibration experiment was performed at Risø National Laboratory with participants from the USA, Eastern and Central Europe and the EU member countries. One aim of the experiment was to intercompare the "home" calibration of detectors and dosemeter responses of environmental radiation monitors used in the above countries and to try to make a link between the different reference standards used. A special feature of this recent intercomparison was the testing of a variety of recent designs of electronic dosemeters to see how they respond to environmental radiation. Another important feature was the use of highly sensitive TLD materials over ultra short integration periods (e.g. 3 hours) to determine the natural background air kerma rate. A total of 12 active dose rate meters, 2 spectrometers, 21 electronic dosemeters and 8 different TL materials were used in the experiments which included (i) free-field and shadow-shield calibrations, (ii) measurement of the natural radiation at the terrestrial field site at Risø and (iii) measurement of the cosmic ray component both on a platform at sea and on a boat at sea.

Table 1. Summary of mean results of air kerma rates from field, cosmic and terrestrial radiations, respectively, for each detector type.

Detector Type (Dosemeter type)	Field, cosmic + terrestrial ($nGy.h^{-1}$)	Cosmic (sea) ($nGy.h^{-1}$)	Terrestrial - field - cosmic ($nGy.h^{-1}$)
HPICs (Dose rate meter)	74.4±1.9	36.4±1.6	38.0±0.8
Pl. Scintillators (Dose rate meter)	71.4±7.8	31.5±6.5	39.8±3.4
GM (Dose rate meter)	68.7	37.8	30.9
Spectrometer (NaI)	45.9±1.9	5.7±1.1	39.9±2.2
TLDs, MCPN	70.0±0.3	28.7±0.1*	41.4±0.4
TLDs, GR-200	67.9±3.6	29.8±1.6*	37.7±1.4
TLDs, Al_2O_3:C	102.5±34.6	37.2±9.6*	65.3±25.0
TLDs, $CaSO_4$:Dy	72.0	30.4*	41.6
Electronic dosemeters (GM)	130±22.4	96.7±19.1*	34.0±4.8
Electronic Dosemeters (Solid state)	96.3±62.5	61.0±53.7*	35.3±12.7

* Estimated from measurements made at the Cosmic Pier Station
N.B. The ± values represent 1 SD.

Table 1 shows the mean results for terrestrial and cosmic measurements for each detector type. Substraction of the cosmic (sea) responses from the field measurement responses yielded mean values of the air kerma rates due to the terrestrial radiation component.

Apart from the Al_2O_3:C material, which will be investigated in future intercomparisons, the TLD results for the terrestrial radiation show good agreement with the active dosemeter results.

CONCLUDING REMARKS

The considerable experience and expertise gained by the participants during the CEC research programme is to be disseminated in a European Radiation Dosimetry Group (EURADOS) Technical Recommendation. This publication will give practical advice on all aspects of environmental photon dose monitoring.

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