RESULTS OF THE EUROPEAN COMMUNITY'S BETA INTERCOMPARISON PROGRAMME OF INDIVIDUAL DOSEMETERS IN 1986

T. Bigard[1], H. Seguin[1], J. Böhm[2], J.-L. Chartier[3], P. Christensen[4], T.M. Francis[5], L. Lembo[6]

1 Commission of the European Communities, Directorate-General of Employment, Social Affairs and Education; Health and Safety Directorate V/E/1; L-2920 Luxembourg
2 Physikalisch-Technische Bundesanstalt, D-3300 Braunschweig, Federal Republic of Germany
3 Commissariat à l'Energie Atomique, CEA-CEN, BP No. 6, F-92260 Fontenay-aux-Roses, France
4 Risø National Laboratory, DK-4000 Roskilde, Denmark
5 National Radiological Protection Board, Chilton, Didcot, Oxon OX11 ORQ, United Kingdom
6 ENEA, PAS/FIBI/DOSI, via Mazzini, I-40138 Bologna, Italy

INTRODUCTION

The expanding use of radioactive sources in industry, medicine and research has led to a growth in the number of persons exposed to beta radiation and has highlighted the need to assess beta doses accurately. The difficulties experienced in the aftermath of the Three Mile Island accident owing to the inadequacies of beta dosimetry, had prompted a fresh look at the state of beta dosimetry within the European Community.

For over 20 years, the Commission of the European Communities (CEC), in collaboration with competent laboratories in the member states, has been conducting intercomparisons of individual dosemeters with the objective of improving technique for monitoring ionizing radiation and establishing a common basis for dose assessment within the Community. These programmes not only serve the participants with an opportunity to validate their calibration and measuring procedures but also help to create a forum in which to exchange information and discuss experience with other participants. The performance and results of such an intercomparison exercise conducted in 1986 are reported here.

Five European laboratories (Numbers 2 to 6 of author affiliations) performed the irradiations of the dosemeters *). Thirty-two laboratories, mainly drawn from the member states, took part in the exercise with 47 dosimetry systems, 31 were equipped with thermoluminescent detectors, 14 with films, 1 with a combination of a thermoluminescent detector and a film, and 1 with exoelectron emission detectors. The dosemeters were irradiated at different orientations with respect to the radiation field with beta rays from $^{90}Sr/^{90}Y$, ^{238}U, ^{204}Tl and ^{147}Pm sources and with gamma rays from a ^{137}Cs source. Neither the radiation quality nor the dose (nominally 5 mSv) was disclosed to the participants.

*) Under contract of CEC

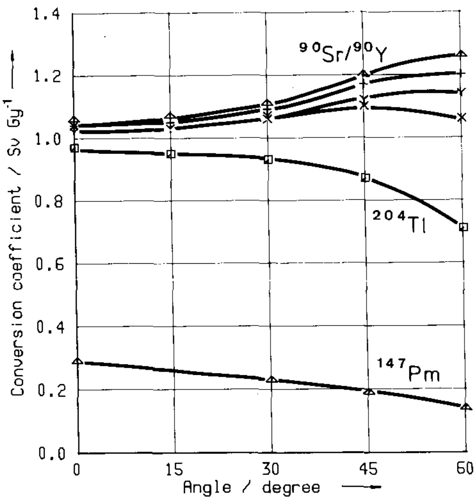


Figure 1: Conversion coefficient as a function of the angle of incidence for beta sources used during the intercomparison programme (four types of $^{90}Sr/^{90}$ sources, one ^{147}Pm and ^{204}Tl source type). The conversion coefficient is defined as the dose equivalent at a depth of 0.07 mm from the surface of a semi-infinite slab of tissue-equivalent material for a particular angle of incidence divided by the absorbed dose to tissue at the surface of a semi-infinite slab of tissue-equivalent material for an angle of incidence of 0°. The angle of incidence is defined as zero if the axis of the beta particle field is perpendicular to the slab.

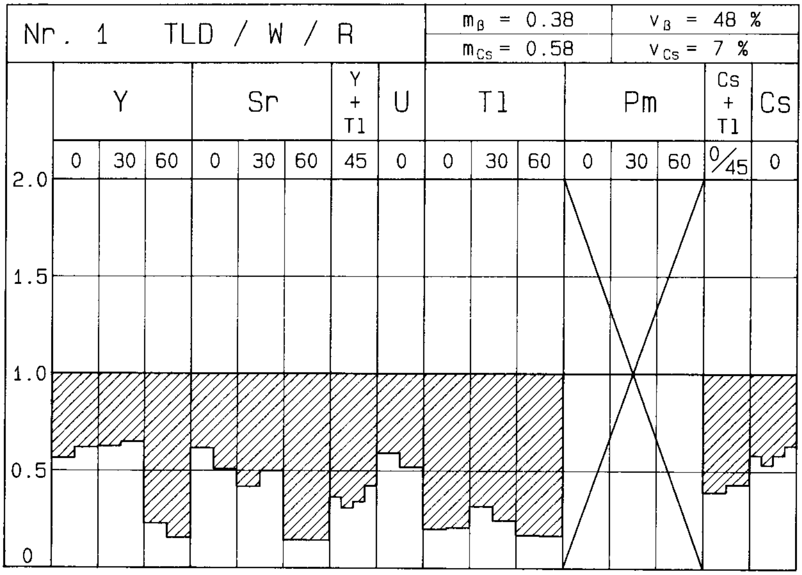
QUANTITIES AND IRRADIATION PROCEDURES

The quantity $H_s(0.07)$ recommended by the ICRU[1] was chosen as the operational quantity. In the absence of a universally accepted calibration quantity or irradiation procedure it was decided to expose the dosemeters to photon radiation positioned on a spherical perspex phantom of 30 cm diameter and to convert air kerma free in air measured at the location of interest, to H'(0.07) by using coefficients derived for this purpose[2].

For beta radiation, however, it was judged that the use of a spherical phantom was not necessary because of the limited ranges of beta particles in dense media, or practicable because of the difficulty of achieving the expanded field condition over such a large phantom at the short distances at which these irradiations are carried out. Instead, the following phantoms were considered appropriate: a perspex slab of 20 cm sides and 1 cm thick for calibrating planar dosemeters and a perspex rod 20 cm long and with appropriate diameter for calibrating finger dosemeters. The calibration quantity in these cases is defined as the dose equivalent at a depth of 0.07 mm from the surface of semi-infinite slab of tissue-equivalent material. It became necessary to determine this calibration quantity for all the beta sources by additional measurements using extrapolation chambers. The conversion coefficients obtained from these measurements (figure 1) allowed the dose equivalent for various angles of incidence to be calculated from the absorbed dose to tissue at the surface of a semi-infinite slab of tissue-equivalent material for an angle of incidence of 0° which is given in calibration certificates[3].

RESULTS

For every dosimetry system the results were shown in a diagram so that the overall performance, as well as the energy and angular dependence of the response, could be seen. The method of



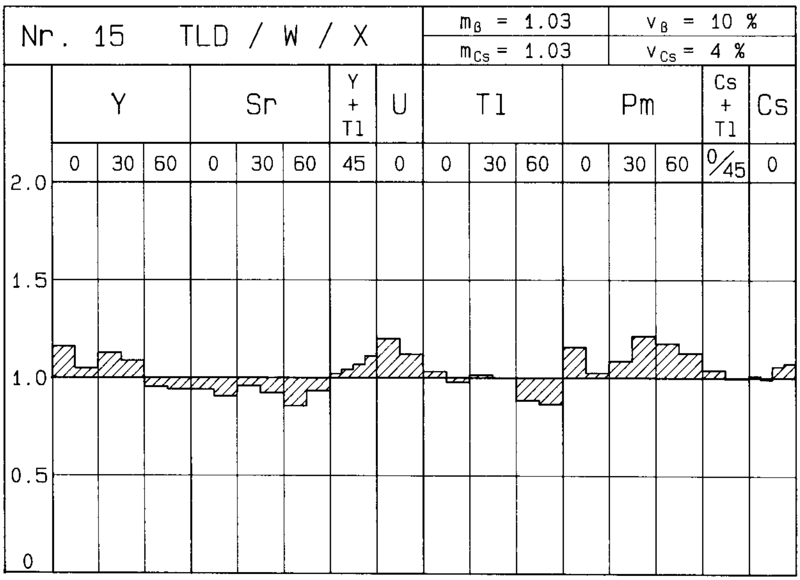


Figure 2: Two examples of results obtained for thermoluminescence dosimetry systems during the intercomparison programme.

presentation is illustrated in figure 2. The left-hand side of the top row contains the number and type of the dosimetry system. The result was calculated as a quotient of dose assessed by the participant by the dose to which the dosemeter was exposed by the irradiating laboratory (taken as conventional true value). For each dosemeter, the value of the quotient falling between 0 and 2 (first column) is represented by a horizontal bar under the appropriate radiation quality (second row) and the angle of incidence (third row). The area between this bar and the line representing quotient value equal to unity is shaded providing a visual indication as to whether the assessment by the dosimetry system is an overestimate or an underestimate. The letter "Y" in the second row indicates the use for irradiation of a $^{90}Sr/^{90}Y$ source with a relatively thick encapsulation whereas "Sr" indicates that of a source with thinner encapsulation, but of the same nuclide. On the right-hand side of the first row, mean values of the quotient for all the beta irradiations (m_β) and that for all the ^{137}Cs irradiations (m_{Cs}) together with corresponding coefficients of variation, v_β and v_{Cs}, are given.

The results of the dosimetry systems show substantial variability. System No. 15 showed the best overall performance for beta radiation (m_β = 1.03; v_β = 10 %). 35 of the 47 systems were unable to measure the low penetrating beta radiation from ^{147}Pm. Only 2 TLD systems using thin or effectively thin detectors were capable of assessing all doses of this intercomparison within ± 40 %. A considerable number of systems showed significant orientation dependence of response even for beta rays of higher energies (from ^{204}Tl and $^{90}Sr/^{90}Y$ sources). Therefore, even if the results obtained for the ^{147}Pm irradiations are excluded, for only 4 systems (3 TLD, 1 film) all the results lay within ± 40 %. This number of systems increases to 16 (9 TLD, 7 film) if 10 % outliers are regarded as being admissible.

A number of participants seemed to have problems when calibrating (at normal incidence) their dosemeters with ^{137}Cs gamma radiation and with $^{90}Sr/^{90}Y$ beta radiation. The m_{Cs} values ranged from 0.58 to 1.42, the corresponding values for $^{90}Sr/^{90}Y$ sources from 0.45 to 1.70. These ranges of values are not considered to be satisfactory. It is noted that some participants had problems with outliers, this being a strong argument for improving quality assurance.

More details of the intercomparison can be found elsewhere(4). Participants found it a very useful exercise in improving the practice of radiation protection and felt that the intercomparison programme should continue. It was felt that there was a need for meetings on the topic of practical beta dosimetry, perhaps to be held on a regular basis.

REFERENCES

(1) ICRU Report 39 (1985)
(2) B. Großwendt et al., Report PTB-Dos-11 (1985).
(3) J. Böhm, Proc.Int. Beta Dosimetry Symp. Washington 73 (1983).
(4) CEC, Proc.5th Information Seminar Rad. Prot. Dosemeter Intercomparison Programme - Beta Dosimetry, Bologna 25-27 May 1987 (in preparation).