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AUTOMATED ANALYSIS IN WHOLE BODY COUNTING OF RADIATION WORKERS

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In order to be able to use the whole body counter of our department for routine measurement of body radioactivity in radiation workers we adapted a commercially available computer program to the special requirements of whole body counting. The software is suited for nuclide analysis of radioactive samples based on gamma ray spectra collected with NaI(Tl) scintillation detectors. We report about our experience in calibrating the instrument, the reliability of peak identification, efficiency, sensitivity and the accuracy of the results.
The measurements of radiation workers show contaminations with activities less than 10% of the maximum permissible amounts. In our experience automated spectrum analysis of gamma spectra obtained by whole body counting offers a useful and fast method for the determination of internal contaminations with an accuracy sufficient for radiation protection purposes.

Introduction

Periodic assessment of internal contamination in radiation workers working with unsealed radioactive sources is part of the investigations required by radiation protection regulations in Austria. The most suited instruments for evaluating body activities of gamma ray emitting radionuclides are whole body counters.

Instrumentation

The whole body counter of our department is of the shadow shield type with a scanning bed geometry. Shielding material is 5 cm lead, with a total weight of approx. 5 tons. The subject is counted on a moving bed with continuously adjustable scanning speed from 12 to 110 cm/min. The total scan length is 275 cm. Two NaI(Tl) detectors (diameter 15.24 cm, thickness 10 cm) one above and one below the subject are used for detection of the radiation (Fig.1).

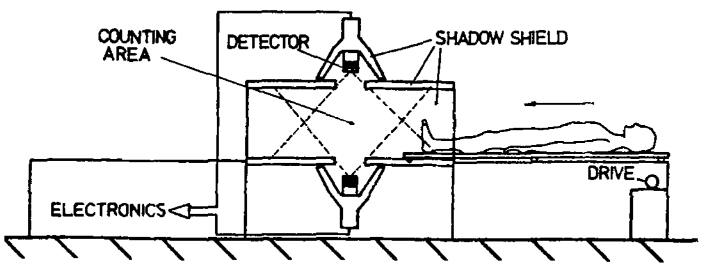

Fig. 1

The minimum detectable activities for some radionuclides are listed in Table I. These activities are several orders of magnitude below the intake limits for radiation workers.

Table I Minimum detectable activity for some radionuclides at 1000 s measuring time

Nuclide	Energy (keV)	Activity in Bq	(nCi)
Tc-99m	141	170	(4.6)
Ba-133	356	163	(4.4)
I-131	364	122	(3.3)
Cs-137	662	96	(2.6)
Mn-54	835	78	(2.1)
Co-60	1333	78	(2.1)

A profile scanning facility using parallel slit collimators is integrated into the counter offering in addition the possibility to locate the radioactivity.

Efficiency calibrations have been performed using calibrated sources in an antropomorphic phantom simulating absorption and scattering in the human body. The efficiency calibration curve obtained for the standard operating mode of the counter is shown in figure 2.

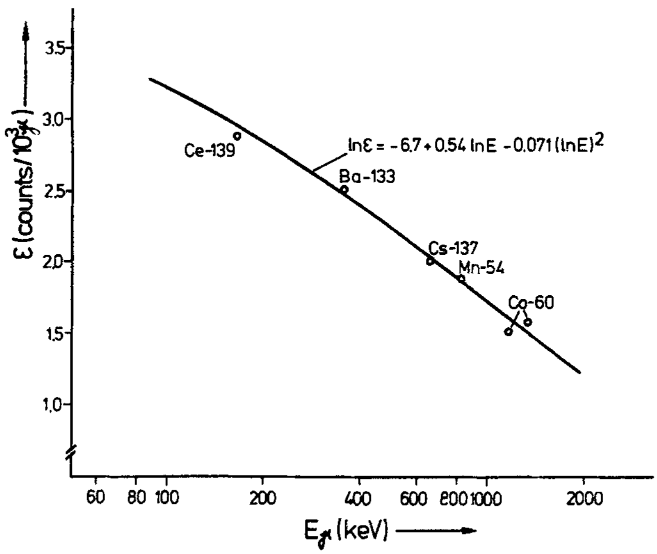

Fig.2. Efficiency calibration curve

Spectrum analysis program

In order to increase the accuracy and to facilitate the evaluation of the measurements we adapted a commercially available spectrum analysis software package (Canberra GAMMA-M, written in FORTRAN-IV, for use on RT-11 and RSX-11M operating systems) to the special requirements of whole body counting. There is the need for frequent and rapid energy and efficiency calibration of the system and also the effect of a considerable fraction of scatter radiation usually present in a spectrum obtained from a subject.

The software is specially suited for nuclide analysis of radioactive samples based on gamma ray spectra collected with NaI(Tl) scintillation detectors. The algorithms include procedures for peak localisation, background subtraction, photopeak identification, area calculation - by fitting Gaussian functions - and peak deconvolution. Reports provide qualitative and quantitative results. Several support utilities are included, such as detector energy and efficiency calibration, multi channel analyzer operation, data storage and retrieval and nuclide library editing.

Calibration

For energy calibration at least 6 different gamma energies are necessary in order to cover the full energy range of radionuclides that can be present in a radiation worker. High accuracy - as necessary for identification of a contaminant - of the calibration curve is obtained by fitting polynomials of higher degrees.

Subject measurement

Special care is required in tuning the system for the best possible energy resolution, since even small distortions of a peak can lead to considerable inaccuracies in the calculated activities.

Measurements with continuous movement of the bed show the disadvantage that the electronic equipment cannot correct for dead time losses by prolonging the counting time. This becomes apparent for activities in the range of kBq (fig. 3). so that for such subjects we take measurements in the step and shoot mode.

Routine measurements on radiation workers show contaminations with the most frequently used radionuclides in our department, such as Tc-99m, In-111, I-131, Tl-201. Our results indicate contamination levels up to 30 times the minimum detectable activities.

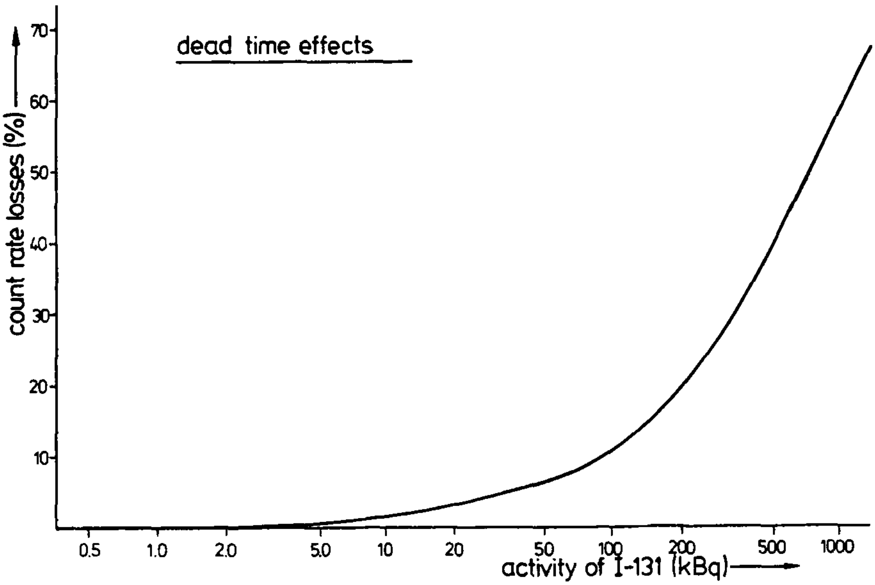

Fig.3. Dead time effects

Discussion

Automated spectrum analysis of whole body measurements offers a useful method for the determination of internal contaminations in radiation workers. The identification of contaminants is facilitated by the use of "radionuclide libraries", which should consist only of the radionuclides suspected to be present in a particular case.

Efficiency calibration is performed by the analysis program using calibrated point sources in a scatter phantom and give calibration values sufficiently accurate for contamination measurements (max 30% deviation from true activity).

The system is easy to use and to recalibrate; the reports of the program are comprehensive and contain all information necessary for further calculations immediately after the measurement.

Literature

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