MEASUREMENT OF ABSORBED DOSE-RATE IN SKIN FOR LOW-LEVEL BETA-RAYS

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A new type of beta-ray absorbed dose-rate meter has been manufactured applying the detection method developed by K. Bingo et. al. (1) to evaluate the absorbed dose in skin at a depth of 7 mg/cm^2 lying above a contaminated sandy beach.

The instrument uses a plastic scintillator with 2.5 mm thick and a single channel pulse height analyzer(SCA) to obtain the best correlation between the instrument response and the absorbed dose-rate.

The absorbed dose-rates for beach sands were measured by the instrument and were compared with the calculated values by the computer code "BETA-SAND" developed by PNC and JAERI (2). With this instrument the absorbed dose-rate of about 2 μrad/hr can be measured by 60 minutes counting.

METHOD AND RESULTS

The beach sands were sampled at eight points around PNC Tokai-works and were dried at about 80°C by a drying oven. The concentration of potassium-40 in the samples were determined by a Ge(Li) spectrometer. The concentration of K-40 in the samples showed a range from 6.3 to 14.9 pCi/g-dry.

The schematic block diagram of the beta-ray absorbed dose-rate meter used in this experiment is shown in Fig. 1.

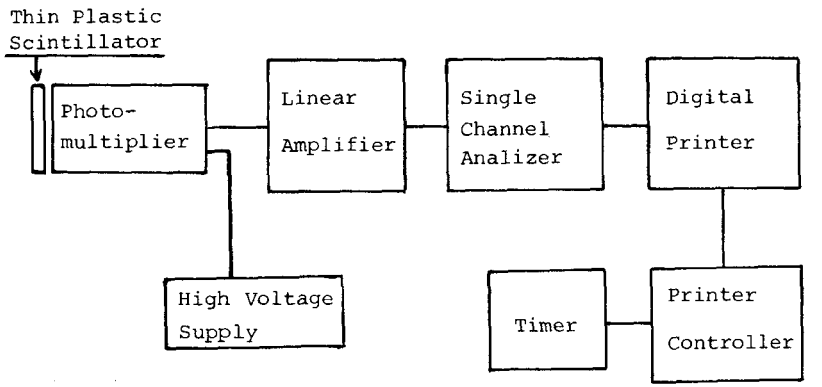

Fig. 1 Schematic Block Diagram of the Beta-ray Absorbed Dose-Rate Meter

The reference beta-ray sources shown in Fig. 2 such as Sr-90/Y-90, Cs-137, Pm-147 and Tl-204 were used to determine the discrimination level and the window width of the SCA. The absorbed dose-rates in skin above the sources were determined by the theoretical value calculated by W. G. Cross (3). The conversion factor obtained from the calibration was 0.4 μrad/hr per cpm for the maximum beta-ray energy ranging from 0.5 to 2.27 MeV. The beta-ray spectra of Cs-137 and Tl-204 measured by the instrument are shown in Fig. 3.

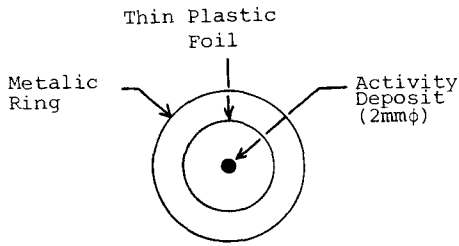

Fig. 2 Reference Beta-ray Source (LMRI made)

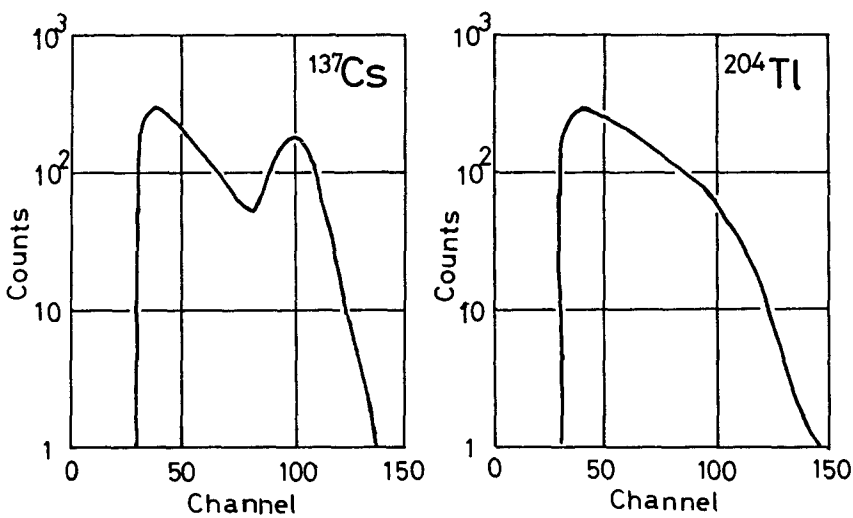

Fig. 3 Beta-ray Spectra of ^{137}Cs and ^{204}Tl measured by the Absorbed Dose-rate Meter

The absorbed dose-rates of the samples were measured by following steps;

(1). Counting the background (C_B) for 60 minutes,

(2). Counting the sample including the background (C_{BS}) for 60 minutes, and

(3). Calculation of the net counts (C_S)

$$C_S = C_{BS} - C_B$$

and the absorbed dose-rates (D)

$$D = (C_S/60) * (\text{conversion factor})$$

An experiment was done to know the relation between the absorbed dose-rate and the depth of sands. The sample prepared for the experiment was adsorbed K-40 on the sand particles. As shown in Fig. 4, the result presents that the absorbed dose-rate is independent with the depth of sands when it is greater than 0.4 g/cm^2.

The dominant natural radionuclide contributing to the absorbed dose is considered to be K-40 (4), so that we compared the measured values and the calculated K-40 dose-rates in the sands. The results of this experiment is shown in Fig. 5 and presents a good correlation.

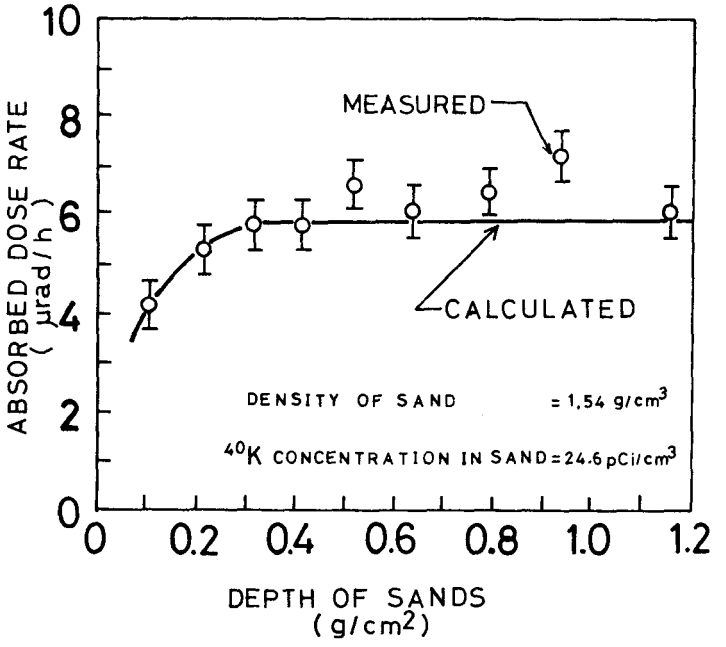

Fig. 4 Change of Absorbed Dose-Rate with Depth of Sands. "CALCULATED" is the Dose Rate by the Beta-ray from Potassium-40 Adsorbed on Particles of Sand.

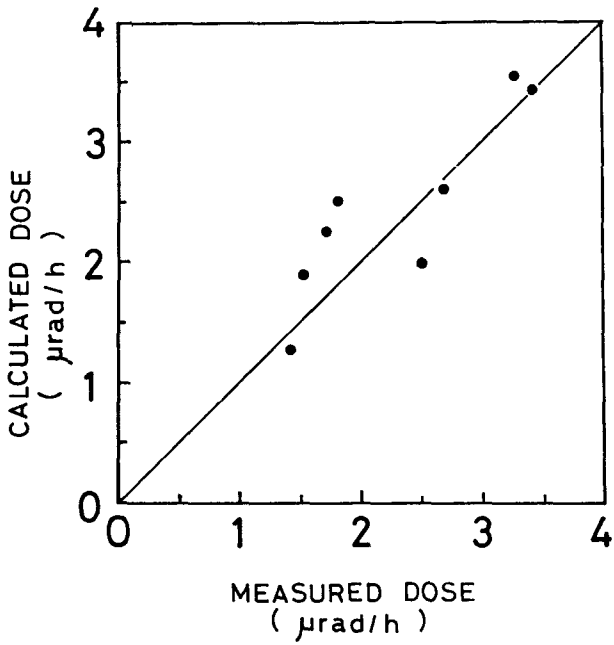

Fig. 5 Correlation between Calculated and Measured Absorbed Dose Rates. "CALCULATED DOSE" is the Dose Rate only by K-40.

SUMMARY

(1). This absorbed dose-rate meter has relatively high stability and sensitivity to measure skin doses.
(2). The measured absorbed dose-rate and the calculated dose-rate has shown a good correlation.
(3). Further study must be made on;
- the influence of the particle size distribution of sands,
- the influence of the water content in the sands, and
- the contribution of the natural radionuclides other than K-40.

REFERENCES

(1) Bingo, K., Chida, T. and Kawai, K. (1976): JAER-M-6753
(2) Itoh, N. et. al. (1977): JAERI-memo-7389
(3) Cross, W. G. (1967): AECL-2793
(4) Miyanaga, I. et. al. (1976): JAERI-memo-6842