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ABSTRACT

Commercial instruments with ionizing chambers are commonly used for the dosimetry of radiation fields. Practical dosimetric procedures are well established in international protocols. In the case of large radiation fields many times the chamber metallic stand, the extension cable and the connector are also irradiated. Undesirable effects can appear with influence on the ionization current measurements. Therefore it is necessary to apply correction factors that depend on the specific case. In this work the effect emerging when the extension cable is exposed to gamma radiation of ^{137}Cs and ^{60}Co sources and to X-radiation with effective energy between 49 and 142 keV was studied. Extension cables from two different manufacturers were tested. The irradiations were all in air, using the systems of the Secondary Standard Dosimetry Laboratory of Institut für Strahlenschutz. Both cables showed similar effects due to radiation. The energy dependence was particularly proeminent for X-radiation energy near 100 keV. Linear behaviour was observed between 5 and 40cm of irradiated extension cable length. The effect is not a negligible one; on the contrary, it has to be taken into account every time an extension cable has to be in a radiation field.

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1. INTRODUCTION

The importance of dosimetry of radiation fields used in Radiotherapy has been realized since the very first applications of ionizing radiations in Medicine and Biology, and continuing efforts are being devoted by radiation researches to the development of more reliable, effective and safe instruments, and to the further improvement of dosimetric accuracy for all the types of ionizing radiations used.

For the dosimetry of the radiation fields commercial instruments with ionizing chambers are commonly used. Practical dosimetric procedures are well established in international protocols (ICRU 1969, ICRU 1970, ICRU 1984).

Many times in the case of large radiation fields the chamber metallic stand, the extension cable and the connector are also irradiated. Undesirable effects can appear with influence on the ionization current measurements. Therefore it is necessary to apply correction factors that depend on the specific case. In this work the effect emerging when the extension cable is exposed to gamma radiation of ^{137}Cs and ^{60}Co sources and to X-radiation with effective energy between 49 and 142 keV (190 and 300 kV) was studied. The linearity of the effect was also investigated.

2. EXPERIMENTAL PROCEDURE

The experiment consists to expose a certain length of an ionization chamber extension cable to radiation. The chamber shall not be irradiated in the same beam as the extension cable; otherwise the effect could be easily masked. But an electric signal from the chamber is needed. Therefore the effect is obtained when the ionization chamber is put in the proximity of (or into) a radioactive check device for instance.

Extension cables from two different manufacturers were tested. Together with them, thimble chambers (0.3 cm^3) with their respective electrometers and radioactive check devices were used. All ionization current measurements were corrected for the ambient conditions of temperature and pressure, when using unsealed chambers. In order to obtain a signal the lowest possible, the chambers were not entirely inserted into the radioactive check devices.

The irradiations were made all in air using the facilities (Eckerl and Nahrstedt 1981) of the Secondary Standard Dosimetry Laboratory of Institut für Strahlenschutz, GSF, Munich.

In the case of gamma radiation, the ^{137}Cs and ^{60}Co sources were used with radiation fields of 10 x 10cm^2, at 38 and 100cm respectively and with exposure rates of 2.58×10^{-5} $C.kg^{-1}s^{-1}$

($0.100\ Rs^{-1}$) and $3.66 \times 10^{-5}\ C.kg^{-1}s^{-1}$ ($0.142\ Rs^{-1}$).

The 420 kV X-ray installation was used with the radiation qualities (Seelentag et al 1979) of Physikalisch-Technische Bundesanstalt (PTB): Table 1. In this table the current and exposure rate values measured can also be observed. The inherent filtration was 4mm Aℓ in order to obtain X-rays with the calibration qualities for therapy dosemeters. The source-extension cable distance was maintained at 100cm and the radiation field, at $10 \times 10cm^2$. In the case of 300 kV the irradiated extension cable length was varied between 5 and 40cm, in order to investigate a possible length dependence of the observed effect.

Ionization current measurements were taken five times before and after the extension cable exposure to radiation. The average of these values (named base current i_0) was compared for each situation with the obtained average value (i) of also five measurements taken during the cable irradiation. The difference ($i - i_0$) was divided by the exposure rate ($\dot{X}$) to the cable and by the irradiated cable length (L). The results are presented therefore in $CR^{-1}cm^{-1}$*. For comparison reasons, they were normalized to a base current of 1×10^{-12}A.

3. RESULTS AND CONCLUSIONS

Both tested cables showed similar effects to radiation. Figure 1 presents the ionization chamber response per exposure rate and irradiated cable length in function of the incident radiation energy. This is the energy dependence of the effect. It is particularly proeminent near 100 keV. In the cable A case, a peak appears in the curve at 98 keV and in the cable B case, at 121 keV. One of the authors (P.P.) had taken measurements at PTW laboratories and observed an alike behaviour as in the present work in the same energy region with a peak arising around 100 keV also. Cable A presents negative responses for ^{137}Cs and ^{60}Co radiation while cable B, only for ^{137}Cs radiation.

Linear behaviour can be observed in Fig. 2 for the effect in question between 5 and 40cm of irradiated extension cable lenth. In this case the response was obviously not divided by the cable length. For this experiment cable A was used.

* In order to avoid misunderstanding, in this work the results are presented using the Roentgen as unit for exposure. For this case ($CR^{-1}cm^{-1}$), the SI units would lead to very strange combination of units ($kg.cm^{-1}$), that do not express the situation at all.

The reproducibility of all measurements was better than 0.70% (1σ) for both cables.

The presented effect is not a negligible one; on contrary, it has to be taken into account every time when an extension cable has to be in a radiation field.

The curves from Figures 1 and 2 can not be used directly. They are characteristics of each extension cable. Each clinical dosemeter user has therefore to determine the curves for its system. The present work has the main objective to draw attention to this kind of effect.

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Table 1: 420 kV X-ray installation
Inherent filtration: 4mm Aℓ

VOLTAGE kV	ADDED FILTER mm Cu	HVL mm Cu	EFF.ENERGY keV	CURRENT mA	EXPOSURE RATE 10^{-5} C.kg^{-1}.s^{-1}	EXPOSURE RATE 10^{-1} R.s^{-1}
100	0.15	0.29	49	15.3	1.85	0.718
150	0.5	0.92	74	15.6	3.25	1.26
200	1.0	1.7	97	15.6	4.93	1.91
250	1.6	2.6	121	15.6	7.35	2.85
300	2.2	3.4	142	14.3	9.80	3.80

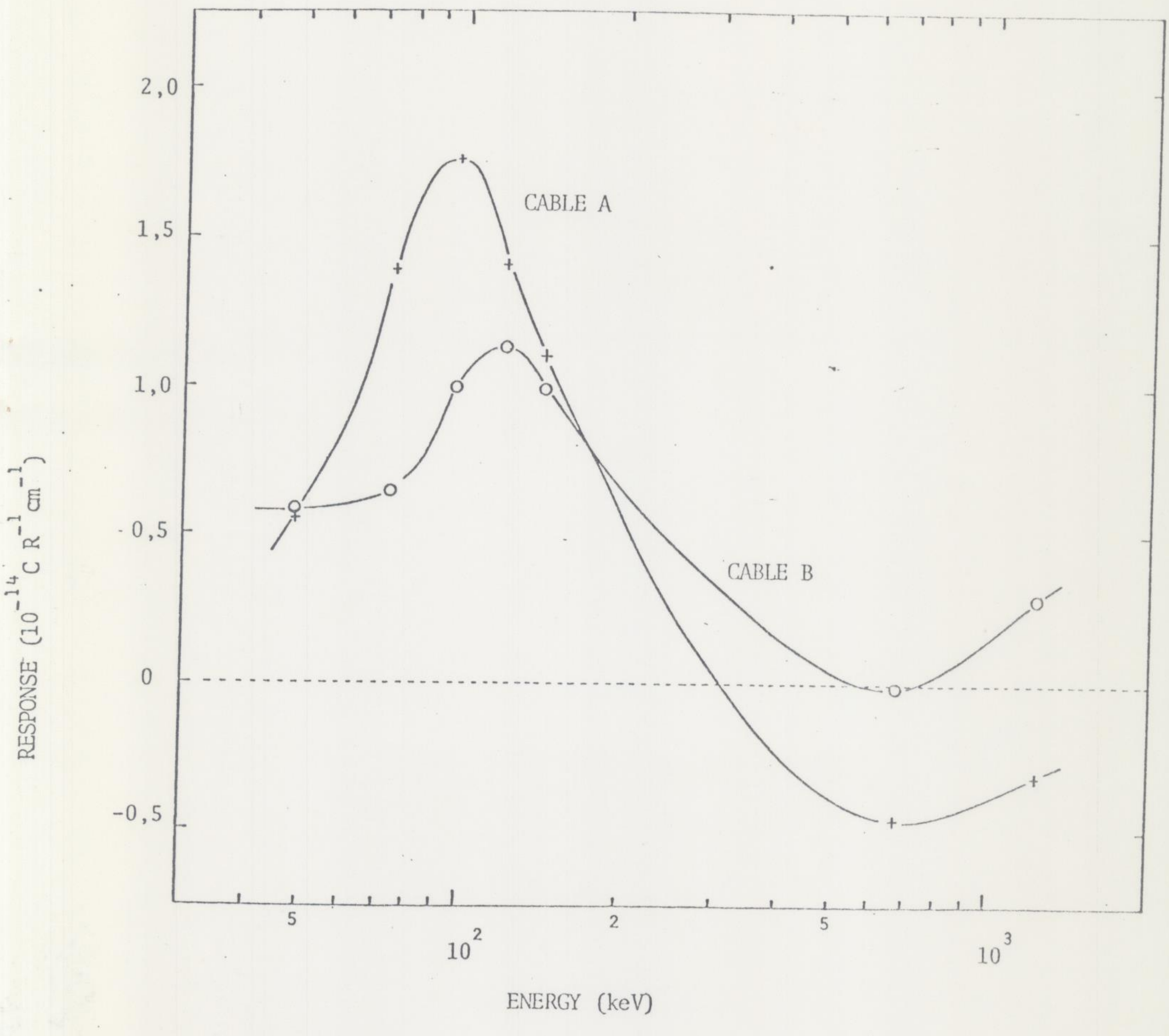

Fig. 1: Energy dependence of the effect.

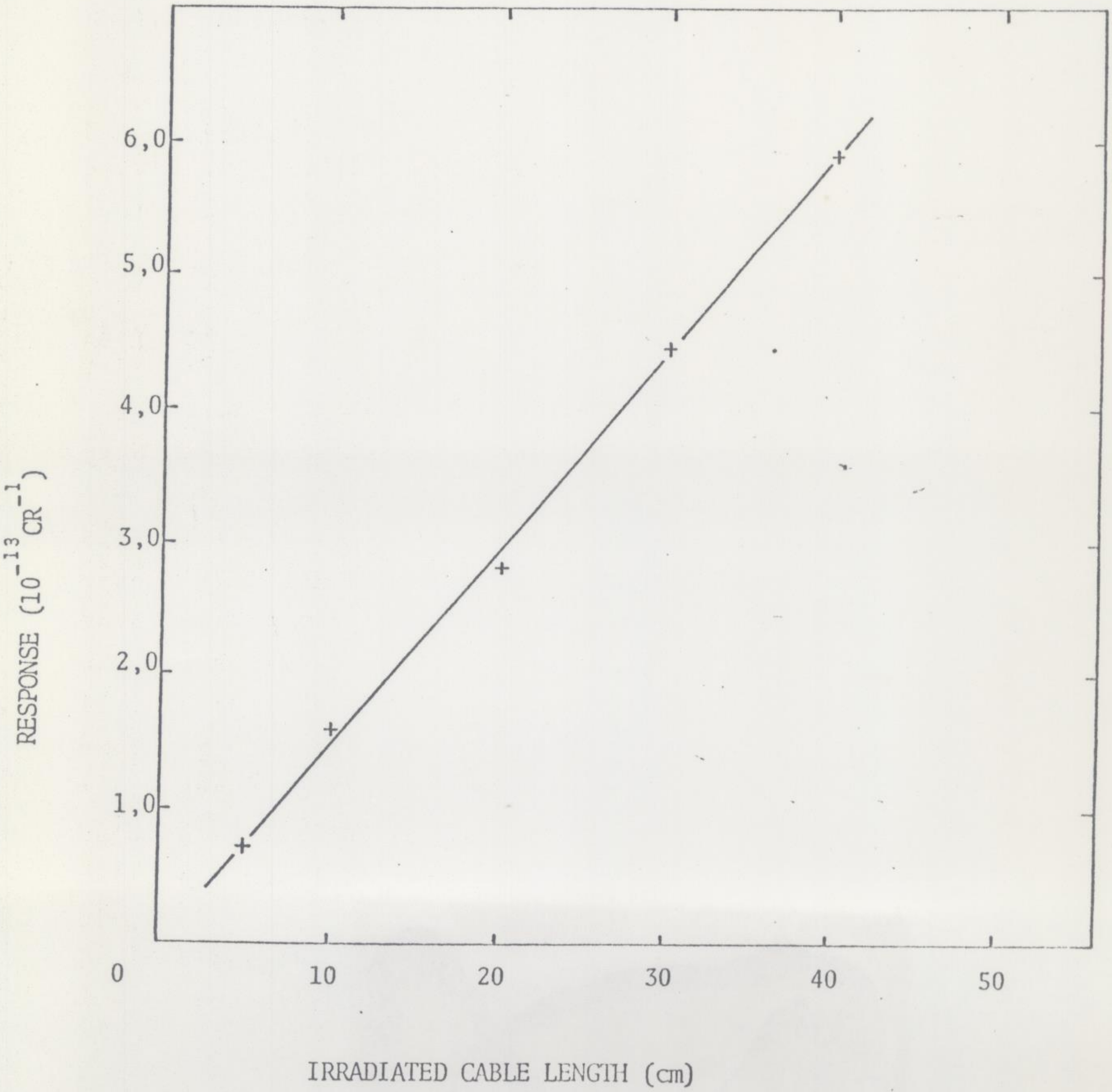

Fig. 2: Linearity of the effect for cable A, with 142 keV X-radiation.