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Systematic discrepancies in standard dose calibration between Japan and Germany

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1. Introduction

We, the Medical Standard Dose center of the Japan Radiological Society, have been calibrating the ionization chambers in terms of the exposure(R/charge) from the radiation therapy facilities since 1972. Japanese center consists of the National Institute of Radiological Sciences as the secondary standard laboratory, that is directly tracable to the Japanese national standard laboratory(ETL) and 13 calibration centers as the third level standard facilities, which cover services in Japan. The Japanese Farmer type standard ionization chambers, named JARP chamber, are maintained constantly and precisely by annual intercomparison measurements among NIRS and 13 centers. The standard deviation of JARP chambers for a given Cobalt-60 gamma-ray field is typically 0.3% to the average.(Kawashima 1997)

At the Tokyo center, we calibrate about 100 ionization chambers from 50 hospitals in Tokyo metropolitan area in a year. Most of the ionization chambers (over 90 %) are manufactured by the Physikalisch-Technische Werkstatten(PTW) at Freiburg, Germany. Each chamber has attached with the certificate of calibration performed at PTW, that is the only secondary standard laboratory directly traceable to the German national standard(PTB). We often experience the dicrepancies of about 2 % in calibration factor for the Farmer type chambers in Roentgen(R)/Coulomb(C) unit, between PTW and Japanese centers. This discrepancy is basically responsible for the national standard laboratories in Japan and Germany. In this report, I have collected, compared and analysed the calibration data for all the PTW chambers calibrated at Tokyo center in the period between January 1997 and June 1999.

2. Materials and Method

Two types of the PTW ionization chambers are most often calibrated; (1) the Farmer type thimble chamber ($0.6cm^3$) and (2) the plate-parrallel ionization chamber, named Marcus chamber($0.05cm^3$). We calibrate the sensitivity of these chambers in term of exposure per charge, in the unit of C/kg per C, or R per C. The certificate of calibration from PTW is attached with the chamber. All the available calibration factors for PTW chambers are collected, compared and analysed.

2-1. Farmer type ionization chambers

The Farmer type chambers, whose commercial names differ from PTW N23333, N30001, M30001 to Victoreen 30-351, or Nuclear Enterprise 2591A. But the serial number(S/N) by the manufacturer is rather consistent. In this period, we calibrated 91 chambers whose S/N ranges from 10 to 2051. 63 chambers are calibrated to the measured charge(C). 19 chambers are calibrated to the Roentgen (R) reading and 7 chambers are calibrated to the absorbed dose(Gy) reading. 22 chambers were available with the certificate of calibration in R/C unit by PTW. And 21 chambers have both PTW and Japanese calibration values. Only 7 chambers are calibrated within 6 monthes after the initial calibration at PTW. In this analysis, these 7 data set is used.

2-2. Plate-Parallel (Marcus type) ionization chambers

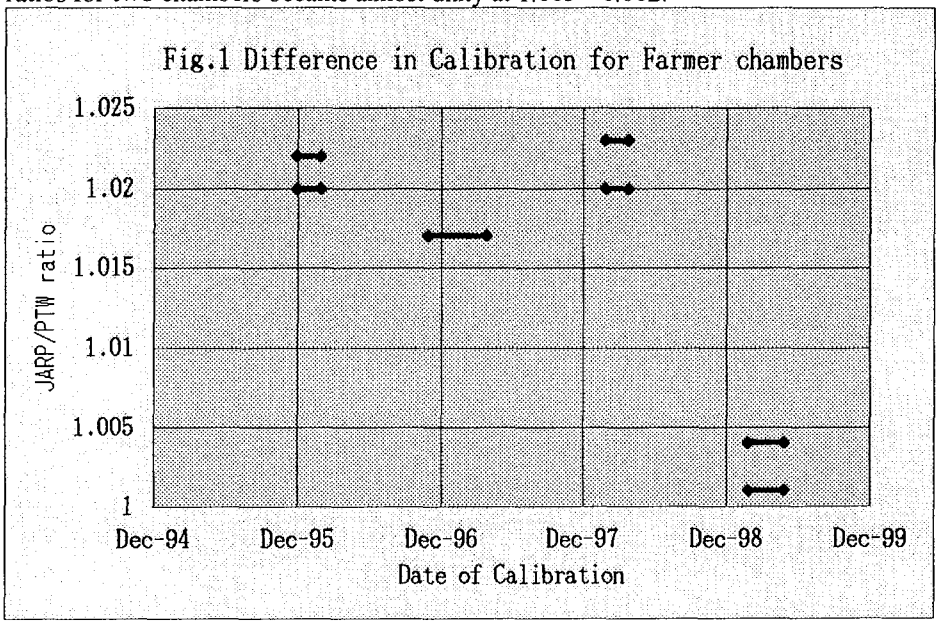
The Marcus type chambers, whose commercial names differ from PTW N23343, W23343 to Victoreen 30-329, or Nuclear Enterprise 2534D. In this period, we calibrated 43 chambers whose S/N ranges from 186 to 2912. 42 chambers are calibrated to the charge(C) reading. One chamber is calibrated to the absorbed dose(Gy) reading. 8 chambers were available with the certificate of calibration in Gy/C unit by PTW. And 7 chambers have both PTW and Japanese calibration values. 6 chambers are calibrated within 12 monthes after the initial calibration at PTW. In this analysis, these 6 data set is used.

3. Results and Discussions

The ratios of calibration factors of two type chambers between PTW and JARP are not only unity but also different for Farmer chamber(exposure) and Marcus chamber(absorbed dose).

3-1. Farmer type ionization chambers

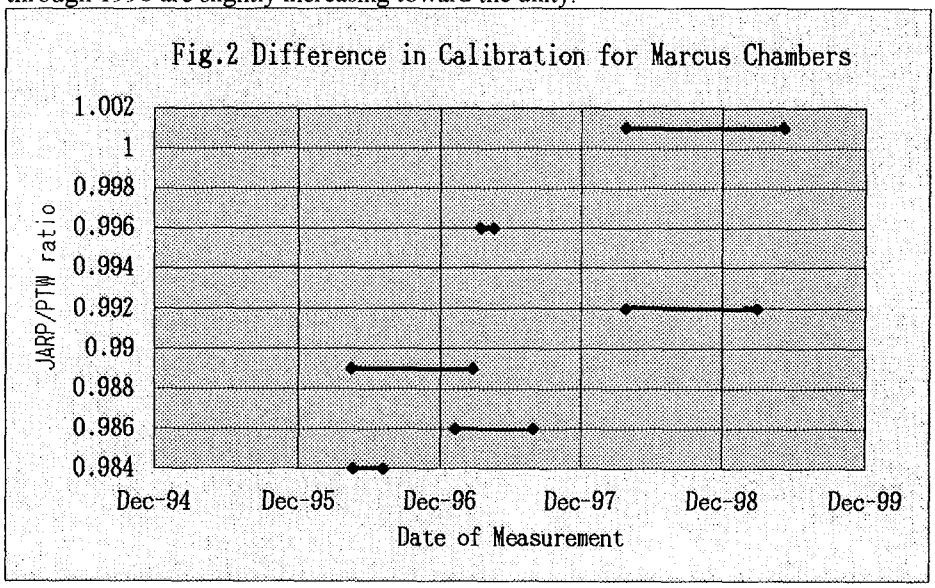
Results: The calibration factors are in R/C unit(typically, 5.586×10^{-9} R/C for S/N=2051) for PTW and R/nC unit(typically, 5.608 R/nC for S/N=2051) for Japanese. Assuming the charge measurement is accurate, the ratio of two calibration factors in JARP/PTW is compared and plotted in Figure 1, as a function of date of calibrations. Two calibration dates, first at PTW and second in Japan, for a given chamber is connected with a thick line. From Fig.1, it seems clear that the 5 calibration ratios in 1995 through 1998 are rather constant at JARP/PTW = 1.020 +- 0.002. However, in 1999 JARP/PTW ratios for two chambers became almost unity at 1.003+-0.002.



Discussions: It became clear that there existed rather systematic and constant discrepancies in exposure calibration factors between PTW and Japanese centers. In 1999, however, JARP/PTW ratio became unity. It is most likely that the calibration factors by PTW have been modofied, as we have not changed the calibration factors of the standard JARP chambers. We need more data to confirm these observation and also we need discussions with PTW on this issue.

3-2. Plate-Parallel (Marcus type) ionization chambers

Results: The calibration factors are in Gy/C unit(typically, 5.564×10^8 Gy/C for S/N=2912) for PTW and R/nC unit(typically, 57.6 R/nC for S/N=2912) for Japanese. The dosimetry protocol for Japanese(JARP) and Germany(DIN) is different.(JARP 1986, Andreo 1994, Iwasaki 1997, Hiraoka 1997) In short, we apply the dose conversion factor of 0.9583 for Cobalt-60 gamma-rays. The ratio of two absorbed dose calibration factors in JARP/PTW is analysed and plotted in Figure 2, as a function of date of calibrations. Two calibration dates, first at PTW and second in Japan, for a given chamber is connected with a thick line. From Fig.2, it seems that the 6 calibration ratios in 1996 through 1998 are slightly increasing toward the unity.



Discussions: It seems that the JARP/PTW ratio is becoming unity. It is most likely that the calibration factors by PTW have been modofied gradually, as we have not changed the calibration factors of the standard JARP chambers, nor the protocol to derive absorbed dose from the exposure measurements. We need more data to confirm these observation and also we need discussions with PTW on this issue.

4. Conclusion

Calibration factors of the PTW ionization chambers have been determined and compared with the initial calibration factors at PTW. In last 3 years, we have calibrated 91 Farmer type chambers and 43 Marcus type chambers. Farmer type chambers are calibrated to exposure (R/C) at both PTW and Japan. There is a systematic difference of 2.0+-0.2 % in the period between 1996 and 1998. However, in 1999 two new chambers show the comparable calibration factors between PTW and JARP. The reason for this change needs to be identified. Marcus type chambers are calibrated to the absorbed dose in water at PTW. We calibrate Marcus chamber in exposure and convert into absorbed dose using a conversion factor(0.9583) for Cobalt-60 gamma-ray. The JARP/PTW ratio for absorbed dose is increasing from 0.984 to 1.00 in the period between 1996 and 1998. However, the protocol to determine the absorbed dose is different between PTW and Japan, further study need to be performed to identify these discrepancies in standard dosimetry.