

## X-ray Dosimetry Standards Intercomparison on the Asia/Pacific Metrology Program (APMP)

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### Abstract

In the 7th Steering Committee Meeting held in November 1986 in Suva, Fiji, the steering committee made a decision that the Korea Research Institute of Standards and Science (KRISS) coordinates the program of the regional intercomparison of ionizing radiation measurement. Through mutual communications with the Radiation Laboratory at KRISS, five countries (Australia, China, India, Japan and Malaysia) agreed to participate in the X-ray dosimetry standards intercomparison under the auspices of KRISS.

Key words : Intercomparison, Calibration factor, Stability check, Transfer ionization chamber, Beam quality, 1st HVL, Tube voltage.

### INTRODUCTION

A regional intercomparison of ionizing radiation standards was performed during 1987 to 1990 on the basis of the 1986 APMP meeting.<sup>1)</sup> Participating countries in the intercomparison included Australia, China, India, Japan, Korea and Malaysia. The list of participants is given in Table 1.

The indirect method was used for the intercomparison. A ionization chamber (NE2577 of KRISS) was circulated to participants who determined the exposure calibration factors for X-rays. After each laboratory calibrated the ionization chamber, the chamber was returned to KRISS for a stability check using a <sup>90</sup>Sr check source.

Table 1. Participants in the APMP intercomparison

Country	Organization	Representative
Australia	Australian Radiation Laboratory (ARL)	N J Hargrave
China	National Institute of Metrology (NIM)	Mian Xu
India	Bhabha Atomic Research Center (BARC)	P. Gangadharan
Japan	Electrotechnical Laboratory (ETL)	I.H. Suzuki
Korea	Korea Research Institute of Standards and Science (KRISS)	S.T. Hwang
Malaysia	Standards and Industrial Research Institute of Malaysia (SIRIM)	Chen Soo Fatt

## EXPERIMENTAL METHOD

The Bureau International des Poids et Mesures (BIPM) recommends two types of methods in the intercomparison of ionizing radiation measurements.<sup>2)</sup> For the direct method, the national standard and the BIPM standard instruments are placed one after the other in the same beam. The field of X-rays ranges from 5 kV to 50 kV. The instrument used for the direct method should be the free-air ionization chamber. For the indirect method, the transfer ionization chamber is calibrated first in the national standards laboratory, then in the BIPM, and again in the national standards laboratory to make sure whether the response condition of the chamber has changed during its circulation. The field of X-rays ranges from 50 kV to 250 kV and <sup>60</sup>Co  $\gamma$ -rays. In case of the indirect method, the exposure calibration factor ( $N_x$ ) is used for data acquisition.

The factor,  $N_x$ , is

$$N_x = \frac{\dot{X}}{I_0} \dots\dots\dots (1)$$

where,  $\dot{X}$  is the exposure rate at the center of the ionization chamber and  $I_0$  is the ionization current which flows in the chamber at the normal condition ( $T_0 = 273.15\text{K}$ ,  $P_0 = 101325\text{ Pa}$ ). The ionization current,  $I_0$ , is

$$I_0 = I \times \frac{T}{T_0} \times \frac{P_0}{P} \dots\dots\dots (2)$$

where,  $I$  is the average current for both polarities of the collecting voltage measured with the chamber at temperature,  $T$  and pressure,  $P$ . The KRISS chose the indirect method for the APMP intercomparison of ionizing radiation in the X-ray energies from 150 kV to 250 kV. The calibration conditions proposed in the intercomparison are given in Table 2.

Table 2. Calibration conditions

Ionizing radiation	Tube voltage	1st HVL	Calibration factor
76 keV X-ray	150 kV	0.88 mmCu	$N_x = \text{kg}^{-1}$
100 keV X-ray	200 kV	1.68 mmCu	$N_x = \text{kg}^{-1}$
125 keV X-ray	250 kV	2.60 mmCu	$N_x = \text{kg}^{-1}$

1. X-ray beam quality  
 2. Tube current : 5 mA  
 3. Distance between focal spot and defining plane : 100 cm  
 4. Beam diameter in the defining plane : 10 cm  
 5. Atmospheric conditions : 293.15 K, 101325 Pa and 50 % RH  
 6. Polarizing voltage : -250 V

The specifications of NE2577 ionization chamber which was circulated to the participating laboratories are given in Table 3.

Table 3. Specifications of NE2577 ionization chamber

1. Sensitive volume	0.22 cm <sup>3</sup>
2. Length	8.7 mm
3. Inner diameter of outer electrode	6.3 mm
4. Outer diameter of inner electrode	1.0 mm
5. Length of inner electrode	7.5 mm
6. Thimble wall thickness	0.36 mm
7. Thimble outer diameter	6.99 ± 0.03 mm
8. Outer electrode material	Graphite 99.999 %
9. Inner electrode material	Aluminum 99.99 %

A report on the APMP intercomparison of ionizing radiation using X-rays has distributed to all the national laboratories that participated in the intercomparison project.<sup>3)</sup>

## RESULTS AND DISCUSSION

The results are summarized in Table 4 and Figure 1. The calibration factor obtained by the participants lie in a range of ± 1% between the values obtained by ARL and KRISS on the basis of the regression analysis using the participant's acquisition data. The stability of the NE2577 ionization chamber as determined using the <sup>90</sup>Sr check source was ± 0.7 %. The stability of NE2577 ionization chamber during its circulation is given in Figure 2 extending from November, 1987 to February, 1990. In the intercomparison, however, no account was taken of the check source data in calculation the results of the calibration factors. In conclusion, it pleases KRISS to note a good consistency of the X-ray measurements performed by the participants and an excellent stability of the NE2577 ionization chamber throughout the intercomparison on the APMP.

Table 4. X-ray beam qualities and calibration factors

Organization	Tube Voltage (kV)	1st HVL (mmCu)	Calibration factor, N <sub>x</sub> (10 <sup>6</sup> kg <sup>-1</sup> )
ARL (Australia)	150	0.89	3.670
	200	1.70	3.708
	250	2.58	3.742
NIM (China)	130	0.506	3.608
	180	1.00	3.647
	250	2.48	3.702
BARC (India)	150	0.56	3.612
	200	1.01	3.633
	250	1.97	3.671
ETL (Japan)	150	0.883	3.636
	200	1.677	3.689
	250	2.603	3.743
KRISS (Korea)	150	0.821	3.596
	200	1.647	3.645
	250	2.556	3.684
SIRIM (Malaysia)	150	0.87	3.629
	200	1.67	3.677
	250	2.62	3.696

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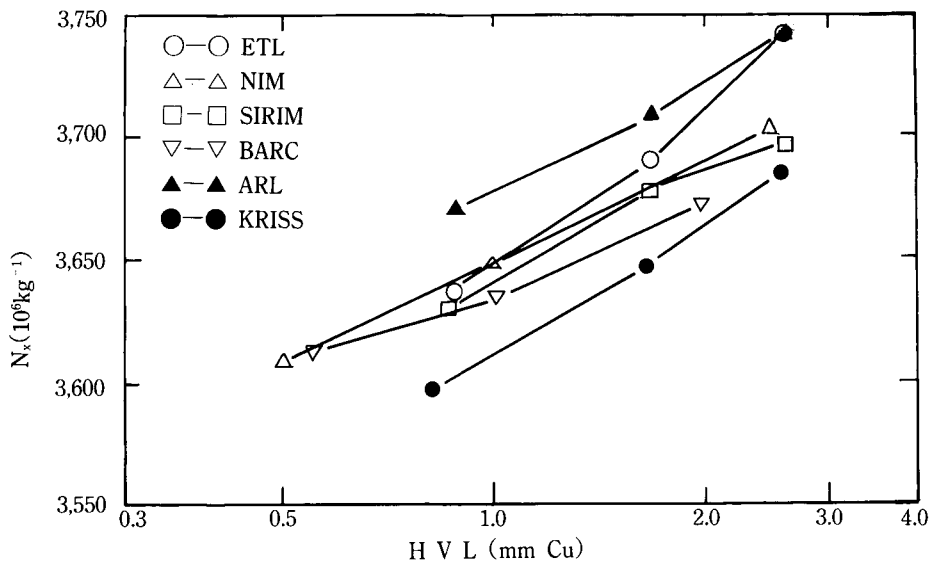


Figure 1. Calibration factor of NE2577 ionization chamber

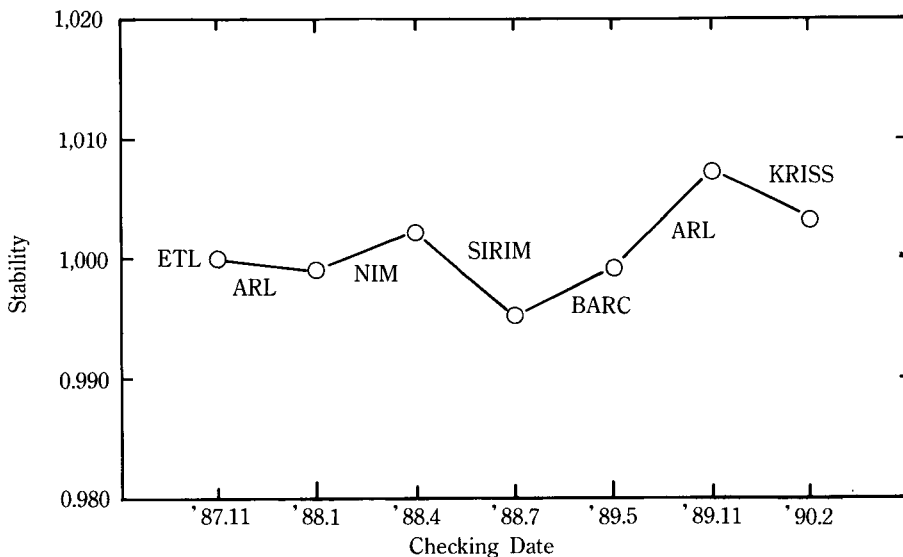


Figure 2. Stability of NE2577 ionization chamber

## REFERENCES

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3. APMP Office of Regional Coordinator, Report on Ionizing Radiation Intercomparison, KRISS, APMP TR-1-92, (1992).

## APMP에 의한 X-선 선량계측표준의 상호비교

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### 초 록

1986년 11월에 Fiji의 수도 Suba에서 개최된 제7차 APMP 준비위원회 회의에서 한국표준과학연구원이 전리방사선 측정의 지역상호비교 프로그램을 주관하도록 결정되었다. KRISS의 방사선연구실은 공식적인 서신교환을 통하여 Australia, China, India, Japan 그리고 Malaysia등 5개국이 X-선 선량계측표준의 지역상호비교 연구에 참여할 수 있는 계기를 마련하였다.