INTERCOMPARISON IN 2016 ON PERSONAL DOSE EQUIVALENT OF Hp(10) AND Hp(0.07) BY OPTICALLY STIMULATED LUMINESCENCE DOSIMETERS (OSLD) IN SOUTHEAST AND SOUTH ASIA REGIONS

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ABSTRACT

The objective of the intercomparison programme is to improve dosimetry systems using optically stimulated luminescence dosimeters (OSLDs) for individual monitoring service (IMS) laboratories in order to comply with ISO-17025. 15 laboratories including 18 participants from 9 countries in Southeast and South Asia regions participated in this programme in 2016. The programme had been designed for OSLDs (type of XA InLight) in which the comparison of deep dose of $H_p(10)$ and shallow one of $H_p(0.07)$ from the participants are included. The dosimeters were irradiated with unknown doses of about from 0.3 mSv to 10 mSv at gamma beam of Cs-137 standard source for Hp(10) and beta beam of Sr-90 one for Hp(0.07). The measured results of the Individual Dosimetry Laboratory (belongs to Dalat Nuclear Research Institute) with code of IO4 by MicroStar reader version 4.3 showed the performance of the evaluation quality for personal dose equivalent with regard to Hp(10) and Hp(0.07) in gamma and beta fields, respectively, in compliance with the trumpet curve with the maximun relative error of 10.4%. Therefore, it could be affirmed that reading OSLDs for determining personal dose at the Institute has had confidence and will be applied in IMS for radiation workers.

Keywords: *Interconparison, personal dose equivalent, Hp(10), Hp(0.07), optically stimulated luminescence dosimeter (OSLD)*

I. Introduction

Optically stimulated luminescence (OSL) is one of the best techniques for passive personal dosimetry. Therefore, it has become common among individual monitoring services (IMS) laboratories in Southeast and South Asia regions. The OSL dosimeter (OSLD) evaluated in term of $H_p(10)$ and $H_p(0.07)$ is based on the whole body dose algorithm. The intercomparison is a crucial procedure for assessing the performance of OSLDs used in IMS laboratories according to the standard of ISO-17025. The objective of this intercomparison programme aimed to reveal confidence between measured dose from IMS laboratories and true dose from the Secondary Standard Dosimetry Laboratory (SSDL) belongs to Office of Atoms for Peace **(**OAP), Thailand. 15 laboratories including 18 participants from 9 countries in Southeast and South

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Asia regions participated in this programme. The programme has been designed for the comparison of $H_p(10)$ and $H_p(0.07)$ using Inlight OSLDs. The dosimeters were irradiated with standard source of Cs-137 for the deep dose ($H_p(10)$) and one of Sr-90 for the shallow dose ($H_p(0.07)$). The results showed the performance of the personal dose equivalent evaluation for $H_p(10)$ and $H_p(0.07)$ in gamma and beta fields in terms of compliance with the trumpet curve [1].

According to [2], intercomparison on measuring personal dose equivalent of $H_p(10)$ in gamma field in the West Asia region was used as a guideline to set up this OSLDs intercomparison which followed criteria of RS-G-1.3 [3]. The announcement of the SSDL, OAP to notify about the information schedule and instructions were distributed to IMS laboratories in Southeast and South Asia regions. An information of types of OSL reader and OSLDs for each IMS laboratory was collected. There were fifteen IMS laboratories including eighteen participants from nine countries participated in this intercomparison. Nagase Landauer Ltd. supported all dosimeters and Thailand Institute of Nuclear Technology (TINT) distributed the dosimeters for the all participants including our laboratory with code of IO4.

II. Experimental method

Intercomparison procedure

35 OSLDs (the same type of XA InLight as the OSLDs used at our laboratory) were sent to each IMS laboratory which can be divided into 7 groups. 6 groups composed of known and unknown irradiation doses as in the following: Unknown group A for $H_p(10)$: 0.30 - 0.50 mSv, known one B for $H_p(10)$: 1.00 mSv, unknown one C for $H_p(10)$: 1.00 - 5.00 mSv, unknown one D for $H_p(0.07)$: 1.00 - 3.00 mSv, known one E for $H_p(0.07)$: 5.00 mSv, unknown one F for $H_p(0.07)$: 5.00 - 10.00 mSv and group G for control. The last group was additional dosimeters used as control dosimeters or transport ones. The dosimeters were used for evaluating the background and the transportation dose received by the dosimeters before and after their irradiation, when dosimeters were in scanning process at the airports.

For the irradiation process, 6 groups of dosimeters of the all participants were irradiated by the SSDL, OAP with 662 keV gamma radiation of Cs-137 standard source (with the doses of 0.35, 1.00 and 3.50 mSv at 0 degree angle of incidence) and 2280 keV beta one of Sr-90 standard source (with the doses of 2.50, 5.00 and 8.00 mSv at 0 degree angle of incidence) in term of $H_p(10)$ and $H_p(0.07)$, respectively. Air kerma for Cs-137 and absorbed dose for Sr-90 were traceable to Physikalisch-Techische Bundesanstalt (PTB) in Germany [1].

The results of study included irradiation qualities, response values (measured dose from participant divided by true value dose giving from the OAP) and overall uncertainties for all

irradiations. For assessing the capability of performance requirement of OSLDs, the result of the response (R) was used in the following equation [1, 4].

$$R = H_{pm}/H_{pw} \quad (1)$$

Where, H_{pm} is value measured by the participant, and H_{pw} is conventional true value given by the SSDL.

The results of the intercomparison were evaluated in terms of compliance with the trumpet curve taken from criteria of RS-G-1.3 which given by equation as follows [1, 4]:

$$\frac{1}{1.5}\left(1-\frac{2Hp_0}{Hp_0+Hpw}\right) \le \frac{Hpm}{Hpw} \le 1.5\left(1+\frac{Hp_0}{2Hp_0+Hpw}\right) \quad (2)$$

Where, H_{p0} is lower limit of dose range (H_{p0} = 0.1 mSv for whole body dosimeters).

Intercomparison report

The participants reported with the sheet form as in the application form. After confirmation of the data, OAP reported the result of intercomparison with certificate. The information of report would be composed of irradiation qualities, response values which used method to compare with delivered dose from OAP and overall uncertainties for all irradiations. Also, Organization Group including OAP, TINT and Nagase Landauer Ltd. prepared a draft report for circulation to the all participants for comments and discussion of the results.

III. Results and discussion

Our laboratory carried out the dose reading by MicroStar reader version 4.3 that was presented in the Figure 1 [5]. This reader was supported by Nagase Landauer Ltd in Japan in 2016. Dose evaluation was implemented by our procedure that was established by Nagase Landauer Ltd. before [6].

Figure 1: *MicroStar reader version 4.3 of our laboratory with code of IO4*

The measured results of our laboratory (Expanded uncertainty for the all dose measurement and evaluation were less than 3 with 95% confidential level) in column (3) and comparative ones with true values of the SSDL, OAP in column (4) were presented in the Table 1. From the Table 1, it was shown that relative errors were small (from 0 to 10.4%) and showed a good agreement in both Hp(10) and Hp(0.07).

Table 1: *Comparative and measured results of our laboratory with code of IO4*

Nuclide	Operational quantity	Measured dose, H_{pm} (mSv)	True dose, H_{pw} (mSv)	R = H_{pm}/H_{pw}	Relative error (%)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Cs-137	Hp(10)	0.35	0.35	1.00	0.00
		0.99	1.00	0.99	1.00
		3.27	3.50	0.93	6.57
Sr-90	Hp(0.07)	2.58	2.50	1.03	3.20
		5.29	5.00	1.06	5.80
		8.83	8.00	1.10	10.38

The Organization Group collected, compared and evaluated statistically all the results of measured doses from 15 laboratories including 18 participants. Figures 2 and 3 (given by the Group) illustrated the responses (the ratios of H_{pm}/H_{pw} for Cs-137 dose and Sr-90 one with the same 0 degree incidence angle) in each participant, respectively. From these figures for our laboratory with code of IO4, it was shown that these responses showed a good agreement (closing to the value of one) in comparison with ones of other laboratories in both Hp(10) and Hp(0.07). On the other hand, the standard deviations of responses of low doses were larger than ones of the high dose in both Hp(10) and Hp(0.07) [1].

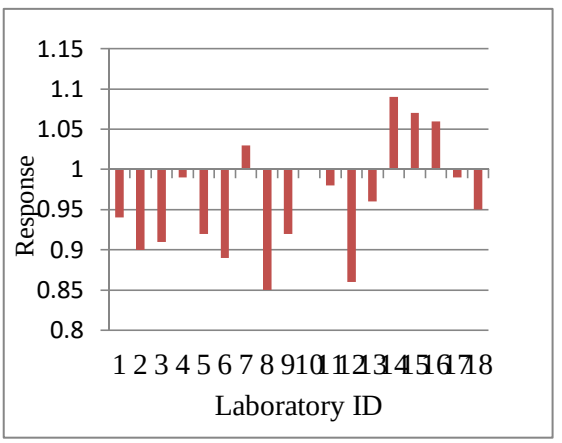

Figure 2: *Response factor of known dose for Cs-137 with 0 degree incidence angle*

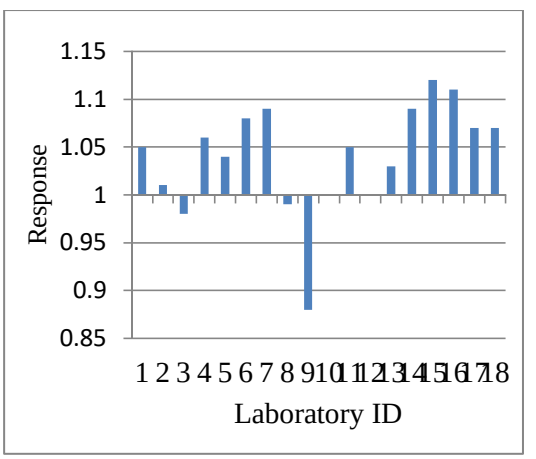

Figure 3: *Response factor of known dose for Sr-90 with 0 degree incidence angle*

Figures 4 and 5 (given by the Group) illustrated the trumpet curves of response factor versus the true dose for Hp(10) and Hp(0.07) in each participant, respectively. In figure 4, the trumpet curve above described upper limit for photon and the trumpet curve below described lower limit for one, and in figure 5, the trumpet curve above described upper limit for beta and the trumpet curve below described lower limit for one. From these figures for our laboratory with code of IO4, it was shown that these responses showed a

good agreement (closing to the value of one) in comparison with ones of other laboratories in both Hp(10) and Hp(0.07). On the other hand, these responses also were within in the upper and lower limits of the trumpet curves [1].

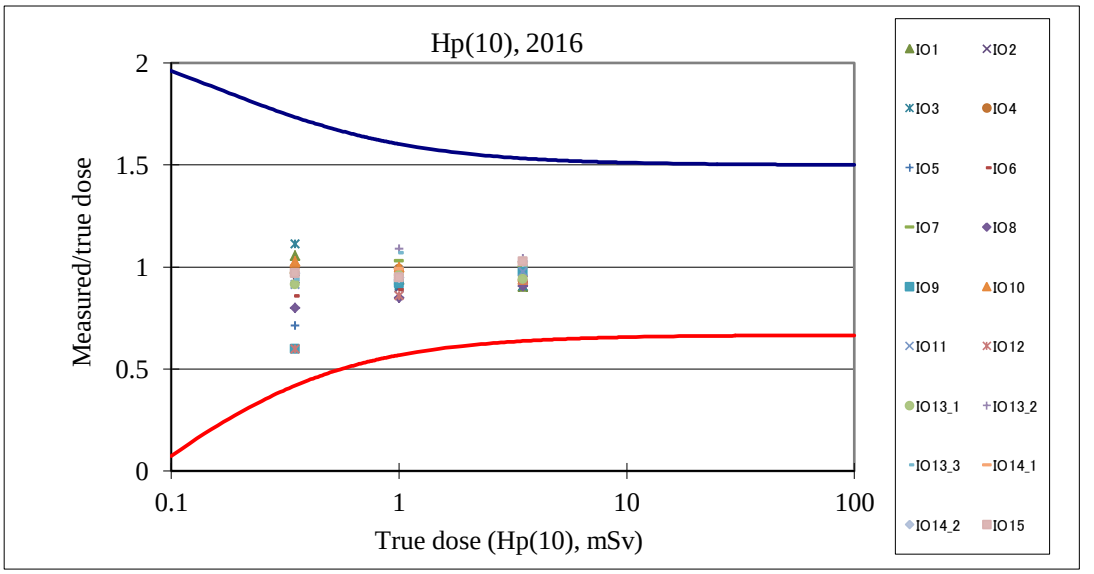

Figure 4: *The trumpet curve of response factor versus the true dose for Hp(10)*

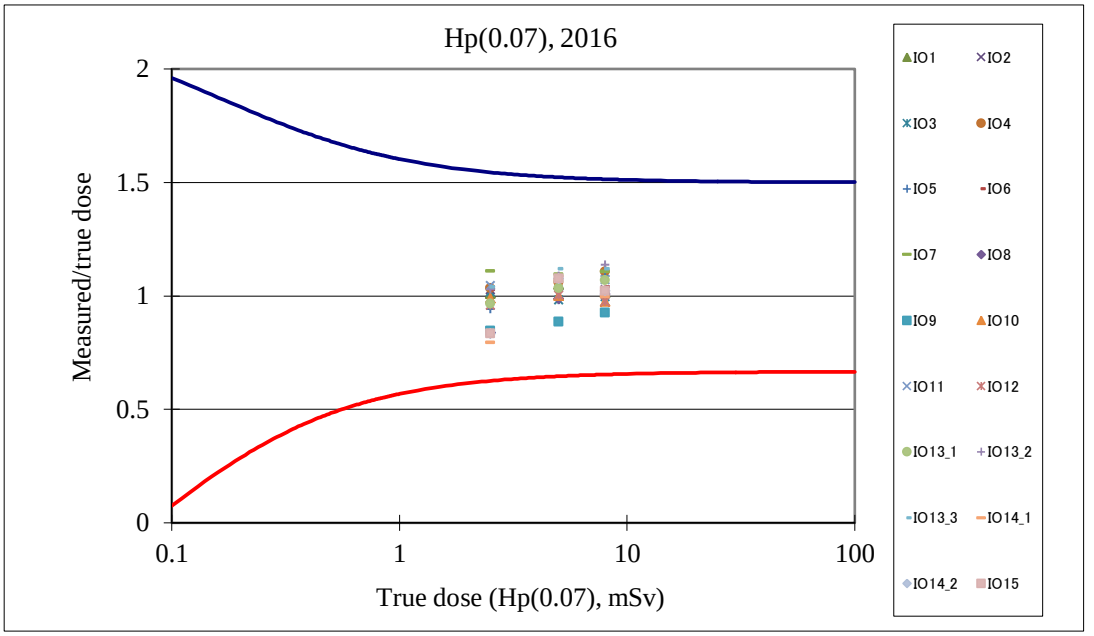

Figure 5: *The trumpet curve of response factor versus the true dose for Hp(0.07)*

IV. Conclusion

Our measured results of the intercomparison are also evaluated in terms of compliance with the trumpet curves, that they showed a good agreement among the IMS laboratories. All response factors of Hp(10) and Hp(0.07) were within the trumpet

curves. The standard deviations of response factors of low doses were larger than ones of the high dose in both Hp(10) and Hp(0.07).

From this result of study, we have prepared all documents for submitting them to Vietnam Agency for Radiation and Nuclear Safety (VARANS) in Hanoi so that our IMS laboratory with using OSLDs could be carried out at Dalat Nuclear Research Institute.

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SO SÁNH QUỐC TẾ NĂM 2016 VỀ TƯƠNG ĐƯƠNG LIỀU CÁ NHÂN Hp(10) VÀ Hp(0,07) BẰNG LIỀU KẾ QUANG PHÁT QUANG (OSLD) TRONG VÙNG NAM VÀ ĐÔNG NAM CHÂU Á

TÓM TẮT

Mục đích của chương trình so sánh quốc tế nhằm cải tiến các hệ thống định liều sử dụng liều kế quang phát quang (OSLD) cho các phòng các thí nghiệm dịch vụ đo liều cá nhân (IMS) phù hợp với tiêu chuẩn ISO-17025. Tham gia chương trình này trong năm 2016 là 15 phòng thí nghiệm gồm 18 thành viên của 9 nước trong vùng Nam và Đông Nam châu Á. Chương trình được thiết kế đối với OSLD (loại XA InLight) cho các thành viên để so sánh các đại lượng liều sâu Hp(10) và liều nông

Hp(0,07). Các liều kế được chiếu xạ với liều chưa biết từ 0,3 mSv tới 10 mSv từ chùm tia gamma của nguồn chuẩn Cs-137 đối với Hp(10) và chùm tia beta của nguồn chuẩn Sr-90 đối với Hp(0,07). Kết quả đo bằng máy đọc MicroStar phiên bản 4.3 của Phòng thí nghiệm Định liều cá nhân (thuộc Viện Nghiên cứu hạt nhân) với mã số IO4 cho thấy sai số tương đối cực đại chỉ là 10,4% so với các giá trị liều chiếu chuẩn ở cả hai đại lượng Hp(10) và Hp(0,07) và nằm trong vùng giới hạn của đường cong "trumpet". Do đó có thể khẳng định rằng, việc đọc liều kế OSL để xác định liều cá nhân ở Viện là đáng tin cậy và có thể ứng dụng trong dịch vụ đo liều cá nhân cho nhân viên bức xạ.

Từ khóa: *So sánh quốc tế, tương đương liều cá nhân, liều sâu ở 10 mm (với bức xạ đâm xuyên mạnh), liều nông ở 0,07 mm (với bức xạ đâm xuyên yếu), liều kế quang phát quang*

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