Inlight Optically Stimulated Luminescence for Occupational Monitoring Service in Thailand.

Waraporn Sudjai
Bureau of Radiation and Medical Devices, Department of Medical Sciences, Tiwanond Road Nonthaburi 11000 Thailand.

ABSTRACT In Thailand, Personal Radiation Monitoring Service is provided by Bureau of Radiation and Medical Devices (BRMD), Department of Medical Sciences (DMSc), Ministry of Public Health by using OSL system, which was selected to replace the old film badge system. Inlight OSL for photon-beta measurement and OSLN dosimeters for neutron measurement were studied by comparison method with delivered dose from Primary Standard Dosimetry Laboratory in Germany. The percentage difference results were found to be 2% for Cs–137, 6.5% for D$_2$O Cf–252 and 37% for Am–Be respectively. For the dominance characteristic, repeated reading and read the dosimeters anywhere and any time, OSL dosimeter were irradiated at Secondary Standard Dosimetry Laboratory in Thailand. After irradiation the same dosimeters were sent to be read at others OSL service providers in Japan, Korea, China, the United State of America and also in Thailand. The percentage difference results were found to be within 10% which were lower than 30% standard criteria defined by the International Atomic Energy Agency. Becoming the first country in ASEAN for using the OSL system, Thailand occupational radiation monitoring service is in the same level as many developed countries and becomes the leading of the service provider in region.

Keywords: Optically Stimulated Luminescence, Occupational radiation monitoring, Personal dose

INTRODUCTION
A service of occupational radiation monitoring using film badge has been set up at the Department of Medical Sciences (DMSc), Ministry of Public Health since 1973. It is a Thai national service provider which served personal dosimeters for nearly 30,000 radiation workers a year in medical industrial and research field. In 2009, InLight Optically Stimulated Luminescence (OSL) was installed replacing all Film Badges. For photon-beta clients, conventional InLight OSL are provided while the InLight OSL neutron type called OSLN are provided for the neutron clients. Element 2 of the OSLN was coated with Li–6 for albedo or thermal neutron detection. The wearing period is normally 3 months but for the high risk of radiation the wearing period is 1 month optional. InLight OSL card composes of a slide and a plastic case shown in fig.1 and fig.2. Four elements of Aluminum oxide (Al$_2$O$_3$·C)
powder are sandwiched between two layer of polyester are positioned on the slide. Different thickness of Al and Cu filters are designed for Hp (10), Hp (0.07) and Hp (3). Individual sensitivity or element correction coefficient (ecc) of all elements determined from a factory can be read via etched code called 2D slide code while the cards are identified by the bar code attached on the case. In the luminescence process\(^{(9)}\), the irradiated dosimeter will be stimulated by a quantum of visible green light from the Light Emitting Diode (LED). During the stimulation only some fractions of populated electrons will be depopulated. The amount of luminescence is proportional to the radiation absorbed and remain unchanged significantly after reading. This characteristic enable the OSL to be read out many times with variation less than 10% for 20 readings.\(^{(5)}\)

The performance testing of the InLight OSL was performed and found to be conformed to the criteria defined by the national approval bodies\(^{(9)}\). Type testing of the system was also done according to IEC 61066\(^{(4)}\). Fading for 3 months storing period at 20°C was found to be less than 1% and less than 10% at 40°C. Lower Limit of Detection\(^{(5)}\) were found to be 40 µSv for 1 month and 60 µSv for 3 months.

In DMSc service system, two automatic 200 desktop InLight readers (fig.3) are calibrated with a set of Landauer calibration cards irradiated by dosimetry laboratory which is traceable to National Institute of Standard and Technology (NIST). There is one mobile reader (fig.4) called Microstar reader is employed for an on-site emergency analysis and for extremity dosimeters service. In this system, computer software for reader control and dose algorithm are integrated. Neutron dose evaluation is also included. In this paper, dose algorithm\(^{(6)}\) for both OSL measurement and OSLN measurement were studied by comparison method. Standard of known doses were given by Primary Standard Dosimetry Laboratory (PSDL) in Germany and evaluated by the system in Thailand. For dominance characteristic, reading the dosimeters any where and any time, the dosimeters were irradiated and read in Thailand after that they were sent to be read at others OSL service providers such as Japan, Korea, China and the United State of America to find out their variation in dose reading.

**Figure 1.** Plastic cover with case and slide inside

**Figure 2.** OSL dosimeter with slide and plastic case
**METHOD**

1. For dose algorithm studied, Inlight OSL and OSLN cards were sent to irradiate at PTB, the PSDL in Germany. Four cards were irradiated with Cs-137 another fours cards with D₂O Cf-252 thermal neutron source. The delivered Hp (10) dose were 2 mSv. Others 16 OSLN cards were irradiated with Am-Be neutron source. The delivered Hp(10) dose lied between 1-4 mSv irradiations were performed on PMMA slab phantom at distance of 1 meter. All irradiated and controlled cards were read and the dose were evaluated. Software built in correction factors were automatically applied for Cs-137 and Cf-252. But for correction of Am-Be, the neutron energy has to be specified to get a proper correction factor. Percentage difference between delivered dose and calculated dose were compared. For Am-Be dose, calibration graph between neutron dose from software calculation and PSDL delivered dose was plotted.

2. For dominance characteristic, reading the dosimeters any where and any time, ten conventional OSL dosimeters were irradiated with X-ray beam quality of N-80 narrow beam representing low photon energy for 2 mSv dose. Another ten dosimeters were irradiated with Cs-137 representing medium photon energy for the same dose. Both irradiations were performed by Secondary Standard Dosimetry Laboratory (SSDL) of Thailand. The irradiated and control dosimeters were read to evaluate Hp (10). After reading, the same irradiated and controlled dosimeters were sent for reading out at others OSL service providers in Japan, Korea, China and the United State of America.

**RESULT**

Percentage difference between calculated dose from OSL reading system and the actual delivered dose given by the PTB are shown in table 1. Percentage
difference for Cs-137 (standard gamma source) and Cf-252 (standard thermal neutron source) were found to be 2.0% and 6.5% respectively. Meanwhile percentage difference for Am-Be were within 1% - 37% for dose range from 1 - 4 mSv. In picture 5, the calibration graph between Am-Be neutron dose from software calculation dose and PTB delivered dose was shown. The correlation coefficient ($R^2$) was found to be 0.9961.

For reading the same irradiated dosimeter at different OSL service providers, the result were shown in table 2. The difference in $Hp(10)$ ratio which is normalized to DMSc reader #84 were found to be within 10% excepted one service provider which was 12%.

Table 1. Percentage difference results of calculated dose software and delivered dose from PTB.

<table>
<thead>
<tr>
<th>Radiation Field</th>
<th>Delivered dose (mSv)</th>
<th>Calculated dose (mSv)</th>
<th>% difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs-137</td>
<td>2</td>
<td>1.96 ± 0.08</td>
<td>2.0</td>
</tr>
<tr>
<td>D2O Cf-252</td>
<td>2</td>
<td>1.87 ± 0.08</td>
<td>6.5</td>
</tr>
<tr>
<td>Am - Be</td>
<td>1</td>
<td>1.37 ± 0.14</td>
<td>37</td>
</tr>
<tr>
<td>Am - Be</td>
<td>2</td>
<td>2.23 ± 0.43</td>
<td>11.5</td>
</tr>
<tr>
<td>Am - Be</td>
<td>3</td>
<td>3.29 ± 0.41</td>
<td>7.3</td>
</tr>
<tr>
<td>Am - Be</td>
<td>4</td>
<td>4.04 ± 0.11</td>
<td>1</td>
</tr>
</tbody>
</table>

![Calculated and Delivered dose](image)

Figure 5. Calibration graph between Am-Be neutron dose from software calculation and PSDL delivered dose.
Table 2. Result of reading ratios from all service providers with respect to DMSc reader # 64.

<table>
<thead>
<tr>
<th>Reader #</th>
<th>Hp (10) ratios from X-ray N-80</th>
<th>Hp (10) ratios from Cs-137</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMSc # 64</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>DMSc # 67</td>
<td>1.00</td>
<td>1.05</td>
</tr>
<tr>
<td>Microstar</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>provider # 1</td>
<td>0.99</td>
<td>1.02</td>
</tr>
<tr>
<td>provider # 2</td>
<td>1.05</td>
<td>1.09</td>
</tr>
<tr>
<td>provider # 3</td>
<td>0.99</td>
<td>1.12</td>
</tr>
<tr>
<td>provider # 4</td>
<td>0.92</td>
<td>0.95</td>
</tr>
</tbody>
</table>

DISCUSSION

From the comparison results using software built-in correction factors, percentage difference for Cs-137 (gamma or photon standard source) was 2% at 2 mSv delivered dose. It was a good result compared to an IAEA occupational intercomparison program which defined the percentage difference at 30% for medium photon energy. For D$_2$O Cf-252 which is thermal neutron standard source, the percentage difference was 6.5%. But for Am-Be neutron source calculation which no built-in correction factor, energy at 41 keV was selected for defining correction factor. OSL system has an advantage feature in repeating reading so selecting energy then read and re-read with other selecting energy can be performed. The percentage difference were within 1% at 4 mSv and 37% at 1 mSv delivered dose. This result agreed in general as deviation of low dose measurement is greater than high dose measurement. The results of calculated dose compared with the PTB delivered dose were used to plot the calibration graph. The trend of this calibration graph was linear between our calibration range 1-4 mSv. Those calibration can be used to evaluate Am-Be neutron dose because all our neutron clients use Am-Be neutron source. However for another neutron source, neutron energy has to be known for correction factor calculation.

Repeated reading of the same dosimeters from different service providers, fading during elapsed time between each reading shall be taking into account, but not in this study. From dominant feature such as individual sensitivity factory defined and reader calibration process, one can read OSL dosimeters anywhere. The percentage different for reading the same card by different readers were around 10%. This may be assumed that, it is possible to perform the inter-calibrated readers by using the same dosimeters without the need to anneal and to re-irradiate. As the dose from the OSL remain unchanged after reading and can accumulate dose up to 10 Sv, ones can continue using any time. In Thailand, it is not compulsory to keep the dosimeters to re-analyze. Repeated reading will be carried out only for high dose resulted. However in our service, we will erase all cards before sending to the clients with A-50 eraser signal machine.
then read the residual signal as a base line dose. When performance testing can not be
done completely by each service provider,
testing results from the third body may be
an alternative for the Quality Assurance
Program. The InLight OSL reader system
can be performed not only at high speed
reading in the laboratory but also can be
performed an on-site emergency evalua-
tion with Microstar reader. Occupational
radiation monitoring in Thailand are now
employed a new efficient and reliable
technology with cost effective. Our service
are also compatible to all other Landauer
service providers in the United State of
America, France(7), Japan and China. By
means of using OSL system, the DMSc
occupational radiation monitoring service
become the leading of the service provider
in ASEAN.

**SUMMARY**

Optically Stimulated Luminescence
(OSL) dose measurement system which
were provided for occupational radiation
monitoring service in Thailand were studied.

For accuracy measurement, the percentage
difference with delivered gamma dose from
PTB was 2% which less than 30% standard
criteria defined by the International Atomic
Energy Agency. But for neutron measure-
ment, the percentage difference was up
to 37%. However there is no standard
criteria for neutron measurement. OSL can
be performed repeated reading, the
accuracy is within 10%. Servicing with the
new technology, Occupational radiation
monitoring in Thailand is in the same level
as many developed countries and becomes
the leading of the service provider in this
region.

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การวัดรังสีบุคคลด้วยแผ่นวัสดุรังสีไอโอดีนผสมในประเทศไทย

วราภรณ์ สุดใจ
สาขาวิชาการศึกษาการแพทย์ กรมวิทยาศาสตร์การแพทย์ ถนนดิวนารี นนทบุรี 11000

บทคัดย่อ สำนักการศึกษาและเครื่องมือแพทย์ กรมวิทยาศาสตร์การแพทย์ ได้นำระบบการวัดรังสีแบบไอโอดีนผสมมาใช้ในการวัดรังสีบุคคลตามระเบียบแวดวงที่ใช้เพื่อการวัดรังสีในสภาวะที่ทดสอบความถูกต้องของระบบประเมินค่าปริมาณรังสีโดยการเปลี่ยนแปลงระหว่างท้องปฏิบัติการ ด้วยการสแกนแผ่นวัสดุรังสีในรังสีด้วยค่านิยมสี่แยกจาก Cs-137 และ Am-Be ทั้งท้องปฏิบัติการรังสีมาตรฐานปฐมภูมิ ณ ประเทศสหรัฐอเมริกา ปรากฏว่าผลแตกต่างของปริมาณรังสีที่มาจากท้องปฏิบัติการรังสีมาตรฐานกับค่านิยมสี่แยกที่ประเมินได้จากระบบเครื่องยาน มีค่าความแตกต่างร้อยละ 2 สำหรับรังสีแบ่งมาจาก Cs-137 ร้อยละ 6.5 สำหรับรังสีแบ่งมาจาก Am-Be ค่านิยมสี่แยกของกิจกรรมลดลงค่ามากแผ่นวัสดุรังสีไอโอดีนผสม โดยผ่านแผ่นวัสดุรังสีที่นิยมสี่แยกมาจากท้องปฏิบัติการรังสีที่ญี่ปุ่นของประเทศไทย ปรากฏที่ท้องปฏิบัติการที่ให้บริการแผ่นวัสดุรังสีไอโอดีนผสมในประเทศไทยทั้ง ๆ ได้แค่ ประเทศญี่ปุ่น เกาหลีใต้ จีน และสหรัฐอเมริกา ปรากฏว่าผลแตกต่างมีค่าไม่เกินร้อยละ 10 ซึ่งแน่นอนด้านมาตรฐานที่ยอมรับได้ไม่เกินร้อยละ 30 ที่กำหนดโดยกระทรวงการประกอบการระหว่างประเทศ การนำเทือนโลโซ่ไอโอดีนผสมมาใช้ในการวัดรังสีบุคคลเป็นประเภทแรกในภูมิภาค ทำให้การวัดรังสีบุคคลของประเทศไทยมีมาตรฐานเดียวกับประเทศที่พัฒนาแล้วหลายประเทศ และก้าวไปสู่การเป็นผู้นำในการวัดรังสีบุคคลในภูมิภาคอาเซียน