Introduction

TLD reader systems used in nuclear power plants at home are either Panasonic or Harshaw, and among these, Harshaw reader systems use DOELAP (2001) for their dose evaluation algorithm except for those at Kori Unit 2 and 3 that use Win-Algorithm (Windows). It came to our attention that the algorithm for skin dose evaluation based on beta energy was missing in Win-Algorithm (ALGM-W05-U-0098-003) provided initially by Harshaw. Upon our request for supplementation, Harshaw provided another algorithm (ALGM-W05-U-0098-003), and this study was launched to examine the adequacy of the new algorithm. Consequently, a completely new algorithm had to be developed as the one provided by Harshaw resulted in under-valuation to a degree when it involved mixed beta field. We are planning to request to Harshaw to set a proper course in the development of a domestic algorithm.

Materials & Methods

1. Exposure to Tl-204 and Sr-90

For this study, Harshaw’s 8814 holders and 7776 Type TLD cards with less than 1% relative standard deviation were selected and then they underwent exposure at the Korea Hydro & Nuclear Power Co., Ltd. TLD exposure dose for algorithm analysis of radiation quality using TLD were performed using the fraction of beta against low photon (L3/L2), and as a result, adequate classification of radiation quality and radiation dosimeter reaction can be used to analyze single exposure to Sr-90.

2. Analysis of radiation quality using TLD

With DOELAP, it is interpreted as being exposed to pure beta field when the L3/L1 fraction exceeds 15, and skin dose correction factor is calculated as below with the L3/L2 fraction, without beta energy classification.

\[ r_{\text{Shallow Dose Factor}} = a_0 + a_1 \times \log(L_3 / L_2) \]

3. Win-Algorithm (ALGM-W05-U-0098-001)

With ALGM-W05-U-0098-001, it is interpreted as being exposed to pure beta field when the L3/L1 fraction exceeds 12, and the average of reactions to Tl-204 and Sr-90 is applied without beta energy classification.

\[ r_{\text{Shallow Dose Factor}} = (r_{\text{Tl-204}} + r_{\text{Sr-90}}) / 2 \]

4. Win-Algorithm (ALGM-W05-U-0098-003)

As for ALGM-W05-U-0098-003, it is interpreted as being exposed to pure beta field when the L3/L1 fraction exceeds 12, and when the L1/L2 fraction is smaller than 0.22, it is classified as Sr-90 and L1/L2 fraction (L1/L2) is less than 0.4, it is classified as Tl-204. All other cases are considered mixed beta ray of Sr-90 and Tl-204, and the average of each reaction is calculated as the skin dose correction factor.

5. New Algorithm

It is interpreted as being exposed to pure beta field when the L3/L1 fraction exceeds 12. The beta energy is classified with the L3/L2 fraction, and the skin dose correction factor is calculated as the same linear–log function as DOELAP.

Results & Discussion

As shown in Table 2, while Win-Algorithm can be used to distinguish beta for single energy, its ability to distinguish mixed beta is rather weak. This is because relative reaction to Tl-204 compared to Sr-90 is 1.74 times lower, and the L1/L2 fraction diminishes when the mix rate of high-energy beta increases. Therefore, classification of beta energy with photon energy fraction (L1/L2) is basically limited, and thus with the New Algorithm, classification is performed using the fraction of beta against low–energy photon (L3/L2), and as a result; adequate classification of radiation quality could be confirmed.

Table 2. Beta Energy Classification by Algorithm

<table>
<thead>
<tr>
<th>Radiation Source</th>
<th>Win Algorithm</th>
<th>New Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tl Only</td>
<td>Tl Only</td>
<td>Tl Only</td>
</tr>
<tr>
<td>Sr Only</td>
<td>Sr Only</td>
<td>Sr Only</td>
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<tr>
<td>Tl and Sr Only</td>
<td>Tl and Sr Only</td>
<td>Tl and Sr Only</td>
</tr>
</tbody>
</table>

Table 1. TLD Exposure Dose for Algorithm Analysis

<table>
<thead>
<tr>
<th>Radiation Source</th>
<th>Exposed to Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tl-204</td>
<td>1.3</td>
</tr>
<tr>
<td>Tl-204</td>
<td>1.5</td>
</tr>
<tr>
<td>Tl-204</td>
<td>2.0</td>
</tr>
<tr>
<td>Tl-204</td>
<td>2.3</td>
</tr>
<tr>
<td>Tl-204</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Fig. 1. Deviation of Skin Exposure Dose by Algorithm

Conclusions

In this study, the advantages and disadvantage of the existing algorithm were examined, and a method to distinguish beta energy as well as skin exposure dose correction factors were developed. Also devised is a positive alternative to performance inspection of low energy beta field of ANSI N13.11–2009, which will be applied in the future. When this method of analysis for special environments is applied, characteristics of exposure radiation quality and radiation dosimeter reaction can be confirmed, which is expected to greatly contribute to optimizing protection management in consideration of radiation quality and to reducing exposure.