AN INTERCOMPARISON OF PERSONNEL DOSIMETERS

by

H. W. Dickson
W. F. Fox
F. F. Haywood

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H. W. Dickson, W. F. Fox and F. F. Haywood
Health Physics Division, Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

An intercomparison of personnel monitoring dosimeters was conducted at Oak Ridge National Laboratory's DOSAR Facility. Ten independent laboratories and companies participated in an intercomparison of neutron and gamma-ray dosimeters used for routine personnel dosimetry. The dosimeters, which were sent through the mail, were exposed at the Health Physics Research Reactor to the same three "standardized" radiation fields which have been used for the past several years for intercomparing nuclear accident dosimeters. In addition, a 14-MeV neutron field was used as a fourth exposure condition. The results of the intercomparison show widely varying dose estimates. The reported values of neutron dose equivalent, for example, have standard deviations ranging from 47-102% of the mean.

*Research sponsored by the Energy Research and Development Administration under contract with Union Carbide Corporation.
SUMMARY

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For the past ten years, the annual dosimetry intercomparisons at the Oak Ridge National Laboratory's DOSAR Facility have provided an opportunity for laboratories in the United States and foreign countries to test dosimetry systems in simulated nuclear accident situations. These studies have been successful in developing guidelines in instrumentation and procedures and in establishing "standardized" radiation fields whose characteristics such as energy spectrum, intensity, and uniformity have been measured and accepted. The Health Physics Research Reactor (HPRR) has been used as the pulsed radiation source. The unshielded reactor and the reactor used with either of two shields—a 12-cm-thick Lucite shield or a 13-cm-thick steel shield—provide three different neutron and gamma-ray spectra.

For this intercomparison, the HPRR and a 14-MeV neutron generator were used to expose personnel dosimeters to mixed neutron and gamma fields. Since dose equivalents of a few hundred millirem are commonly encountered in personnel monitoring, a neutron kerma of a few tens of millirad was needed for the neutron component. A free air tissue kerma of approximately 40 mrad was selected, and the reactor operating time was calculated based on this kerma. The reactor was operated in a steady-state mode at a power level of one watt for the necessary length of time. The neutron generator was operated to produce a similar kerma from the 14-MeV neutrons.

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Generally, the dosimeters were mailed or shipped to the DOSAR a few days in advance of the intercomparison. The dosimeters were returned in a similar manner the day after the intercomparison exposures were completed.

All badges were placed on water-filled trunk portions of Bomab phantoms at three meters from the reactor in the case of the reactor exposures and at one meter from the neutron generator tube in the case of the 14-MeV exposure. When shields were used, they were placed at two meters. The placement of dosimeters on the phantoms is shown in Fig. 1, while a typical experimental arrangement with reactor and shields in place is given in Fig. 2.

Reference dosimetry was performed using sulfur foils to monitor the reactor runs and a tissue-equivalent proportional counter to monitor the neutron generator run. In addition, the neutron dose and dose equivalent for the reactor runs were calculated based on the published spectra,\(^{(3)}\) the fission yield for each reactor run, and the leakage of the HPRR core. A summary of the reference values of neutron dose and dose equivalent for the four exposures is given in Table 1.

A summary of the results is presented in Table 2. Several of the participants gave several dose estimates either due to the use of multiple dosimeters or due to various
means of interpreting their results. The average includes all estimates that the participants claimed to be valid, even those taking into account actual knowledge of the spectra. It is reasonable to expect a more favorable agreement between the several participating laboratories if the results of experimental devices and nonroutine dosimeters are ignored or if a selective data handling technique is used. For example, if the extreme data points are excluded, the resultant average dose-equivalent estimates are $431 \pm 112$, $539 \pm 238$, and $501 \pm 240$ mrem, respectively, for the reactor runs and $409 \pm 154$ mrem for the 14-MeV exposure.

This study was found to be valuable to the participants, and the wide range of results indicate some problems with the response and/or the interpretation of the dosimeters used. This addition to our dosimetry intercomparison program was judged to be worthwhile, and plans are under way to continue these studies in the future.

References


Fig. 1. Typical Placement of Dosimeters on Phantom Section
Fig. 2. Typical experimental arrangement for reactor exposures
Table 1. Reference Values of Dose and Dose Equivalent

<table>
<thead>
<tr>
<th>Run</th>
<th>Spectrum</th>
<th>Dose (mrad)</th>
<th>Dose Equivalent (mrem)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Calculated</td>
<td>Measured</td>
</tr>
<tr>
<td>1</td>
<td>Unshielded HPRR</td>
<td>46.4</td>
<td>36 ± 7.2</td>
</tr>
<tr>
<td>2</td>
<td>Steel-shielded HPRR</td>
<td>55.7</td>
<td>42 ± 8.4</td>
</tr>
<tr>
<td>3</td>
<td>Lucite-shielded HPRR</td>
<td>38.0</td>
<td>35 ± 7.0</td>
</tr>
<tr>
<td>4</td>
<td>14 MeV</td>
<td>43.9</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 2. Summary of Results

<table>
<thead>
<tr>
<th>Exposure Condition</th>
<th>Neutron Dose Equivalent (mrem)</th>
<th>Gamma Dose Equivalent (mrem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Reactor</td>
<td>453 ± 213*</td>
<td>24.6 ± 5.9</td>
</tr>
<tr>
<td>Steel-Shielded Reactor</td>
<td>554 ± 346</td>
<td>18.1 ± 4.3</td>
</tr>
<tr>
<td>Lucite-Shielded Reactor</td>
<td>675 ± 687</td>
<td>75.1 ± 14.2</td>
</tr>
<tr>
<td>14 MeV</td>
<td>587 ± 501</td>
<td>384 ± 151</td>
</tr>
</tbody>
</table>

*Uncertainty expressed is one standard deviation.