Simulation of Radionuclide Production in a Typical VVER-1000 during the Start-Up

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Abstract. Accurate evaluation of the inventory of nuclear reactors at various states is essential for understanding their contribution to the natural background. The Monte Carlo method is currently capable of performing such simulations based on detailed neutron transport calculations. Although some hybrid methods based on coupling a Monte Carlo code (e.g. MCNP) with a burn-up code (e.g. Origen) have been developed, they largely are limited in logic and underlying assumptions. Here we have studied inventory of a typical VVER-1000 during the start-up phase using the well-known MCNPX code. We additionally have assumed that the core is clean and cold in the process.

Introduction
A power-producing reactor is a great source of many different radionuclides which are mostly effective on the efficiency of CTBT verification regime. Some of these methods are based on hybrid procedures in combining a deterministic depletion code such as ORIGEN with a Monte Carlo stochastic transport code such as MCNP. Besides very different available codes, MCNPX has much more superiority over the others, in which it is simple to use and rich in its capabilities for handling sophisticated problems. However, development of a burn-up calculation capability for MCNPX has been postponed to very recent version 2.6. Here we have used MCNPX for simulation of a typical VVER-1000 to study the inventory of some radionuclides during early 38 days of the start-up in its first cycle. The core is assumed to be clean and at the room temperature. We have considered Xe-133, Xe-135, I-131, Cs-137, Cs-134, Cs-136, Te-132, Nb-95 in which they are important for CTBT verification regime purposes. It is mostly effective on the efficiency of CTBT verification regime.

Materials and Methods
VVER-1000 is a light water reactor, having very different specifications in comparison to western PWRs. For the current work, we have assumed a clean core at the first cycle, considering four different average enrichments, in which they are known as fuel assembly types of 16, 24, 36, and 48. We have used MCNPX with the new option of BURN. The simulation was performed with the well-known MCNPX code. We additionally have assumed that the core is clean, and cold in the process.

Discussion
As a conclusion, one can address that MCNPX capabilities in simulation of burn-up is suitable for evaluation of radionuclides inventory in power reactors. For example, comparison of Figure 4 to results of Ref. shows acceptable agreement, keeping in mind that considered reactor is different from those of presented in Ref.

Table 1. Average overall contribution of different fuel enrichments.

<table>
<thead>
<tr>
<th>Enrichment (%)</th>
<th>Contribution (%)</th>
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<tbody>
<tr>
<td>1.6</td>
<td>18</td>
</tr>
<tr>
<td>2.4</td>
<td>39</td>
</tr>
<tr>
<td>3.3</td>
<td>10</td>
</tr>
<tr>
<td>3.7</td>
<td>33</td>
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References