Dose Assessment for Tritium Releases During Normal Operation of NPP

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Main source of tritium in the Czech republic are NPPs Dukovany and Temelín, both PWR Type.

Doses to population from tritium and other radionuclides in the discharges from NPPs are very low, much lower than authorized limits.

However, calculation of doses from tritium has some problems from the point of view of its RBE and therefore, often it is a target of anti-nuclear activists.

Aim of this work was to find out how realistic are the estimation of doses to public, and if too conservative, to suggest more realistic approach.
Dose constraint and authorized limits for discharges of radionuclides into environment in the Czech Republic

Dose constraint for total discharge of radionuclides – 250µSv per year for a representative individual from public (200µSv for airborne discharges, 50µSv for liquid discharges)

On the basis of optimization process, site specific authorized limits are set for NPP
NPP Dukovany: 40µSv airborne and 6µSv liquid discharges
NPP Temelín: 40µSv airborne and 3µSv liquid discharges
Characteristics of the NPPs in the Czech republic and doses to public from their releases.

<table>
<thead>
<tr>
<th>Nuclear Power Plant</th>
<th>Dukovany</th>
<th>Temelín</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power output</td>
<td>4x440MW</td>
<td>2X1000MW</td>
</tr>
<tr>
<td>Releases to atmosphere (Sv)</td>
<td>1.6E-08</td>
<td>8.0E-09</td>
</tr>
<tr>
<td>Releases of tritium (Sv)</td>
<td>3.20E-10</td>
<td>6.40E-11</td>
</tr>
<tr>
<td>Releases to hydrosphere (Sv)</td>
<td>1.80E-06</td>
<td>1.10E-06</td>
</tr>
<tr>
<td>Releases of tritium (Sv)</td>
<td>1.80E-06</td>
<td>1.10E-06</td>
</tr>
</tbody>
</table>

Doses from liquid releases during normal operation are 2 to 3 order of magnitude higher than from airborne releases. In liquid effluents and therefore in overall dose to population, dose from tritium is dominant. Tritium is the only one radionuclide measurable in the environment (in the rivers). Doses to public are calculated using models of transport of radionuclides in environment in combination with measured released activity of radionuclides into air and water.
Austria Slovakia

Germany

Volume activity H-3 [Bq/l]

Poland

NPP Temelin

Praha

Volume activity H-3 [Bq/l]

NPP Dukovany

Germany

Austria

Slovakia
Annual releases to atmosphere and hydrosphere from the Czech Nuclear Power Plants Dukovany and Temelín
Annual releases of tritium, normalized to power output, from NPP PWR to air and water (geom.mean)
The old model calculation of population doses took into account releases through ventilation stacks into atmosphere and liquid effluents into hydrosphere only.

However, in Dukovany NPP the source of cooling water is water from the river dam with the outfall of liquid effluents from NPP. Significant activity of tritium is escaping into air by the way of the cooling towers, contributing thus to the dose from air releases and diminishing dose from hydrosphere.

Activity of radionuclides in cooling water is measured periodically in NPP, amount of water vapours is calculated from flow rate above and below NPP.
Ventilation stacks (HTO, HT) $5.7 \times 10^{11}$ Bq

Cooling towers

To the dam: $8.9 \times 10^{12}$ Bq

To cooling towers is returning $3.99 \times 10^{12}$ Bq

Net to river: $4.9 \times 10^{12}$ Bq

$0.5 \times (3.99 \times 10^{12})$ Bq (HTO vapor and drops)
A computer code PTM_HTO has been developed to assess the dose to general public. It takes into account HTO, HT and water drops (1 – 3 % of the released activity of $^3$H). Oxidation of HT to HTO and reemission of HTO from soil to the atmosphere are included too.

Organically bound tritium (OBT) in vegetations, milk and beef is taken into account.

In the same way as in the old model local consumption is assumed (e.g. that all products consumed are locally produced – very conservative approach)
Validation of PTM_HTO Model on the data from field experiment

Experimental vs. Theoretical Data

Example for releases in 2008

Ratio of doses to individual from released $^3$H calculated by modified transport models to the original one

<table>
<thead>
<tr>
<th></th>
<th>A2/A1</th>
<th>B1/A1</th>
<th>B2/A1</th>
</tr>
</thead>
<tbody>
<tr>
<td>hydro,i</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hydro,a</td>
<td></td>
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<td></td>
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<tr>
<td>atm,i</td>
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<td></td>
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<tr>
<td>atm,a</td>
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</tbody>
</table>

Doses to individual per unit of released $^3$H activity

- **A1** – without OBT, without releases through cooling towers
- **A2** – with OBT, without releases through cooling towers
- **B1** – without OBT, with releases through cooling towers
- **B2** – with OBT, with releases through cooling towers
Change of normalized doses from tritium with modification of transport model

- A1 – without OBT, without releases through cooling towers
- A2 – with OBT, without releases through cooling towers
- B1 – without OBT, with releases through cooling towers
- B2 – with OBT, with releases through cooling towers

**Ratio of normalized doses to individual**

- **hydro, i**
- **hydro, a**
- **atm,i**
- **atm,a**

**Exposure pathway, representative individual**

- [Graph showing the change of normalized doses with different exposure pathways and conditions]
Conclusions.

Doses from tritium to population from the Czech NPP are very low (below 2µSv),

When OBT is included, doses from airborne discharges increase by about 30%. Increase of doses from water discharges, which are dominant, is less than 10%.

Taking into account recirculation of cooling water, overall doses from tritium from NPP Dukovany decreased about 50%.

Such approach would be not practical for limitation purposes as the amount of water evaporated through cooling towers is known ex post only. However, for reporting annual doses, a realistic approach would be appropriate.