Modelling the Activation of Reactor Components for Radiation Protection and Decommissioning

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For some years now the dismantling and subsequent storage of the large components, e.g. steam generators and reactor pressure vessel, have been taken into consideration in decommissioning strategies in Germany. The aim is to store the highly activated materials until a treatment becomes considerably less involved and to reduce the dose rate for the workers. Also the volume of the material to be disposed of can be reduced if the radioactive material fulfills the clearance levels. A basic quantity for the assessment of the decay storage is the exact knowledge of the relevant radionuclides in the activated material in order to track their decay over time. An activation and shielding sequence has been developed in order to calculate this inventory and the resulting dose rate. The sequence will be applied to two cases with two different geometrical models. In one case, a generic German PWR is studied with the aim to assess the decay storage. In another calculation the activation of the WWER-440 Greifswald reactor is calculated and the resulting dose rates will be compared to the available data in order to validate the model. The calculations scheme involves basically four steps:

1. Neutron Flux Calculation
2. Activation
3. Source Term Generation
4. Calculation of Dose Rate

The calculations were performed with five different transport libraries with up to 175 energy groups. The results basically agreed very well, and only at the outer positions, where the flux is very low, some deviations occurred. In Figure 2 the total flux and the thermal flux relative to the flux in the core are shown. The figure shows the qualitative behavior, which is the same for all libraries. At the axial outer positions beyond the vessel, the flux increases compared to regions inside the vessel. This increase is due to a streaming and backscattering of the flux off the concrete structures and partially also off the reactor pressure vessel. This behavior can not be discovered in one-dimensional models.

**Neutron Flux Calculation**

The first step is to determine the neutron flux of the nuclear facility under operating conditions. For this task the GRS-code-system DORTABLE is used, which is based on the deterministic two dimensional transport code DORT. DORT is used in RZ geometry and the configuration includes the whole pressure vessel with internals and surroundings up to the bioshield (Figure 1).

**Activation**

As a first test, the activation of a headscrew and a squeeze nut of the bottom nozzle of a fuel element have been calculated. The results have been compared to measured concentrations of eleven isotopes. As an example, Figure 3 shows the calculated concentration of Cobalt 60 in comparison to data. The results agree very well and a similar agreement can be found for the other isotopes.

**Figure 2:** Total and thermal flux relative to the core in comparison to the geometry.

**Figure 3:** Co60 activity of the squeeze nut as a function of position.

**Neutron Flux Calculation**

*Figure 1: DORTABLE model of the Konvoi-type PWR.*

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