Topic 1 (Oral)

How can a potential moderation and/or reflexion of the neutrons between the fuel units be modelled to give the maximum of the k-effective - No equivalence between a water layer and a mist

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Context

Up to the end of the 90's, a quasi equivalence was considered in the criticality studies between a water layer (with a thickness corresponding to the maximum of the reactivity) and a mist of any density. This equivalence was often used in the studies, firstly when, for safety matters, the quantity of water in the room was not limited, secondly to take into account the reflection of the neutrons by the different devices that were not represented in the criticality calculations.
In practical, most of the people performing calculations used to consider one or the other type of model; Actually, some previous studies showed that both types of the water representation gave equivalent results, as soon as the quantity of water was varying in the total range of its possible values.

Issue

While performing a study on fuel slabs (Uranium-Aluminium) for a storage, it was decided to represent potential moderation between the fissile units by a mist of a varying density. The k-effective values obtained were lower than the safety limit of 0.95. However, the storage facility indicated that there was a bag containing hydrogen atoms near the fuel elements. Then it was decided to take this bag into account and to model it by a water layer of a varying thickness: the maximum of the k-effective obtained increased by 3% (Δk) in comparison with the previous one.

Therefore it was decided to perform other calculations with the same fuels but with a distance between the fuel varying. It showed that the maximum of the reactivity is not always obtained with a water layer. In fact, for a large distance between the fuel units, the maximum of the reactivity is reached with a water layer; for a small distance between the fuel units, the maximum of the reactivity is obtained with a mist. The k-effective difference between one model (water layer) and the other (mist) can be greater than 9% in Δk.

Studies

This article presents the different configurations studied (different distances between the fuel units) with different types of fuels: U-Al slabs, MOX fuel rods, Pu239 fuels.

Some preliminary explanations are also given showing that the differences observed were not due to:

- the Monte Carlo Method; Sn calculations were performed showing the same effect,
- the model used to represent the water anisotropy (P1).

Then, the importance of the different distributions of the absorptions and leakage of the neutrons is studied, for a given configuration, depending on the two types of models for the water reflexion/ moderation and on the distance between the fuel units; some explanations are proposed concerning the fact that:

- the mist leads to higher k-effective when the fuel units are separated by a "small" distance,
- the water layer leads to higher k-effective when the fuel units are separated by a "large" distance.

This article points out the problem of "how can a potential moderation and/or reflexion of the neutrons between the fuels units be modelled to give the maximum of the k-effective". Therefore, it proves that there can be some very important differences in k-effective between the two types of model and, if the person in charge of the calculations uses only one type of model when there are some important absorptions and/or leakages of the neutrons in the system, he **can under estimate** the maximum of the k-effective by **more than 9% in Δk**.