Criticality accident in case of a spent fuel pool dry-out

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In case of a severe accident of a storage pool of spent fuel assemblies, the loss of cooling may lead to a dry-out. Fuel assemblies are designed so that a decrease of the water density in the reactor core leads to a decrease of the core reactivity. But what about a decrease of the water density in the pool? In the present case of a pool containing 625 undamaged UOX PWR 17x17 assemblies with a water density lower than 1 g/cm³ on 1.5 meter-height, the nuclear criticality hazard is evaluated and possibilities for the detection of a potential criticality accident are discussed.

**EVALUATION OF THE HAZARD**

On the following graphs are drawn remarkable areas of $\Delta k_{eff}$ (the difference between the neutron multiplication factors ($k_{eff}$) computed with the CRISTAL package for dry-out configurations and for the reference configuration of common safety cases: fresh fuel assemblies immersed in unborated water):

With basic bounding assumptions (no boron in water, fresh fuels), an unsafe area appears for storage pools designed with a pitch between assemblies higher than 25 cm. The risky water density range of the water mist (boiling water or water injection) is reduced when the pitch increases. What about more realistic assumptions?

**DISCUSSION ABOUT POSSIBLE EVIDENCE**

Evidence of a criticality accident occurring in a spent fuel pool should be based on specific consequences of a fission chain reaction: a creation of fission products (FP) and an important emission of neutrons.

**Detection by fission products**

An adequate FP for the detection of a criticality accident shall 1/ have a high fission yield 2/ have an effective decay time short compared to the cooling time of the fuels 3/ spread easily 4/ be easily measurable.

Evolution of the concentration of selected FP (obtained with VESTA calculations) in a UOX fuel after a typical 35GWd/t irradiation in a PWR, followed by a criticality accident occurring 30 or 365 days after the fuels unloading.

Some fission products created during a criticality accident can be evidence that this accident is occurring or has occurred, even for spent fuels. Nevertheless, the detection of such fission products is to be considered only as possible evidence and thus should be confirmed by other facts. For example, neutron monitoring could be an effective additional mean to detect a criticality accident in a dried-out spent fuel pool.