EUROSAFE

Towards Convergence of Technical Nuclear Safety Practices in Europe

Nuclear criticality safety of enriched UF6 cylinders

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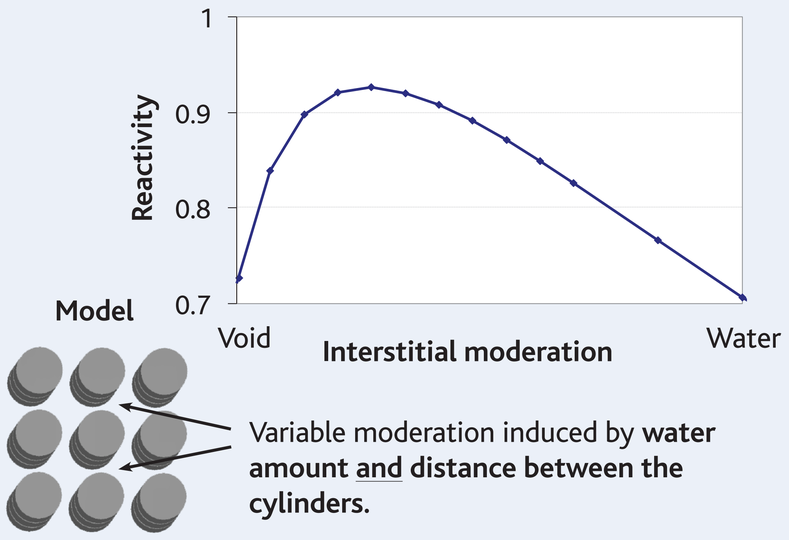
The sub-criticality of enriched UF6 cylinders must be guaranteed during their transport as well as during their storage in nuclear facilities. This paper shows the impact of main parameters on reactivity: interstitial moderation, steel wall thickness, uranium mass, cylinders stacking and presence of residues in the content. These parameters may have non-intuitive impact on k-effective or are not always studied.

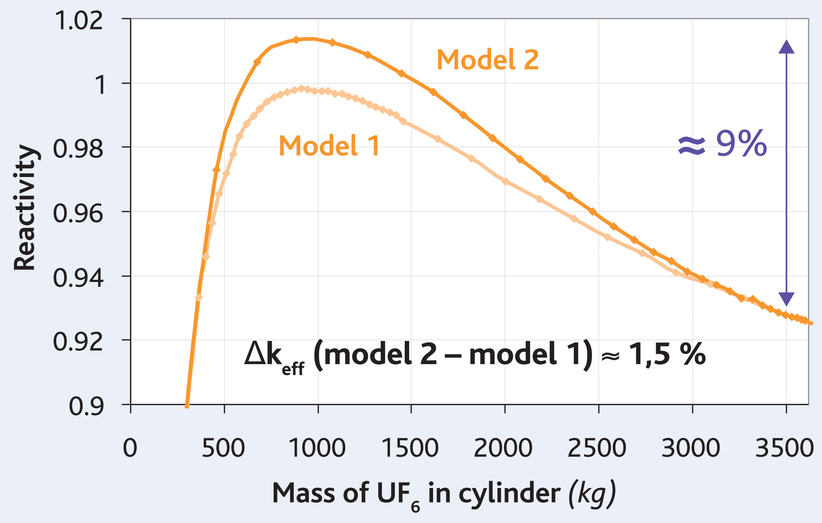
This work is based on infinite arrays of 30'' cylinders filled with enriched UF_6 (5wt.% ^{235}U). All the impurities in UF_6 (0.5wt.%) are assumed to be HF. The content is then **UF_6-0.1HF.**

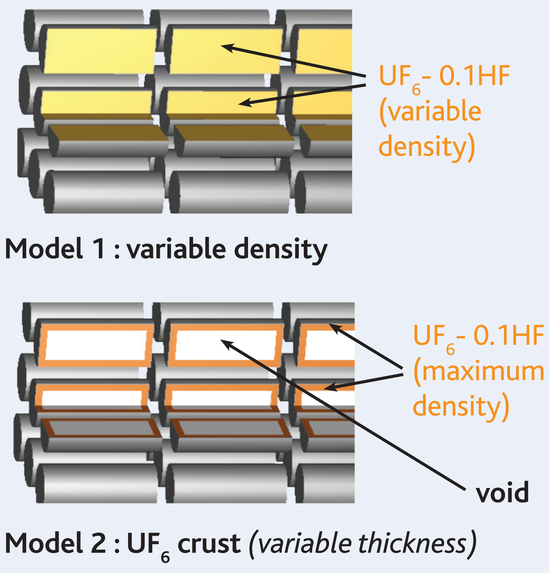
EVALUATION OF TRANSPORT OR STORAGE OF CYLINDERS

a) Interstitial moderation impact on reactivity

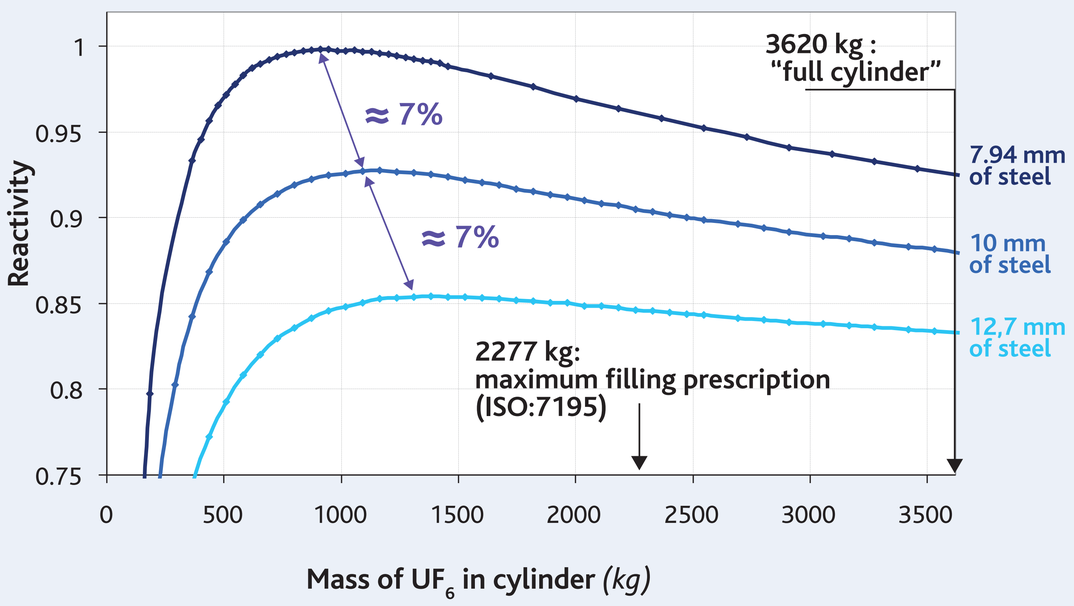


b) Mass of UF6 impact on reactivity



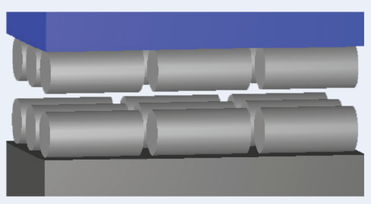


c) Mass of UF6 and steel cylinder thickness impact on reactivity

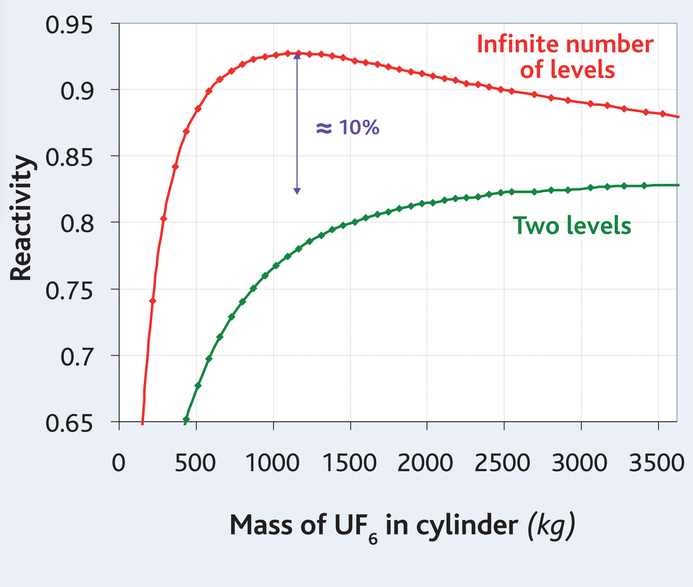


d) Stacking impact on reactivity

Industrial configuration (1 or 2 levels)



Model configuration: plan array on 2 levels



For an infinite number of cylinders, the highest reactivity can be obtained when cylinders are partially filled of UF_6 and spaced out (to obtain an optimal amount of water between them (a), (b)). Note that the impact of UF_6 mass depends on the steel thickness of the cylinder and on the number of stacking levels of cylinders in the configuration. For instance, the reactivity is higher for partially filled cylinders when the steel thickness around them is lower than 12.7 mm (c), and for full cylinders when they are stacked on two levels only (d).

IMPACT OF URANIUM RESIDUES IN THE CYLINDERS

During cylinders' engagement (or accosting) and disengagement for the filling or the extraction of uranium hexafluoride and during long storage periods, some air in-leakage is possible and results in the hydrolysis of UF_6 and the creation of non-volatile uranium residues (in particular UO_2F_2). Because cylinders are not always washed, the presence of such residues is possible in an empty cylinder.

Uranium residue composition and mass in cylinder

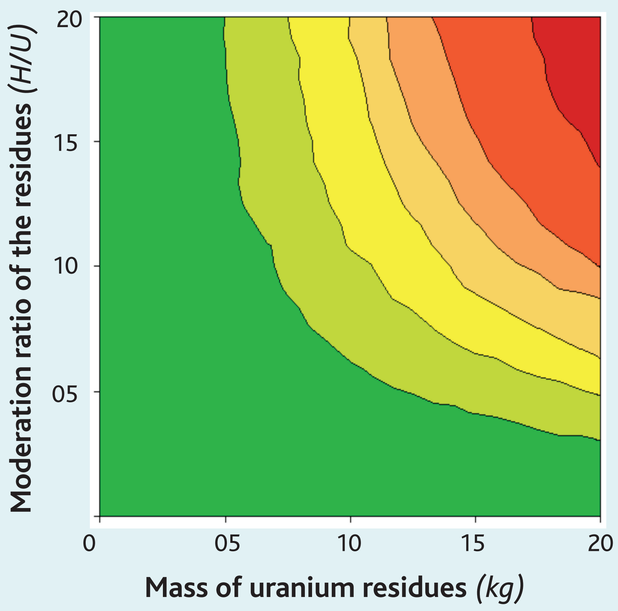
Hydrolysis reaction: $UF_6 + 2\,H_2O \rightarrow UO_2F_2 + 4\,HF$

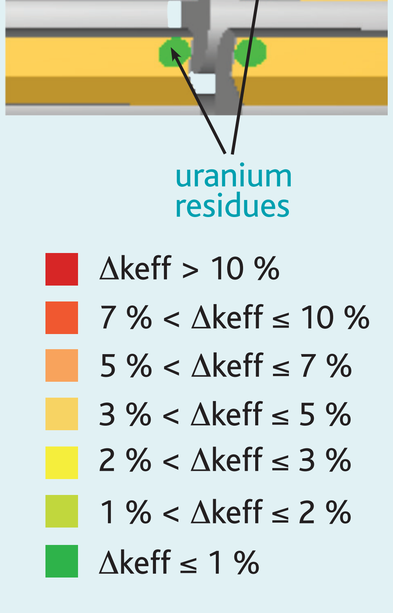
UO_2F_2 reaction with water and HF ➔ $UO_2F_2\text{-}xH_2O\text{-}yHF$

According to scientific literature, the ratio H/U in UO_2F_2 complex (2x+y) varies between 0 and 11.

In ISO:7195, the maximal mass of these residues is 11.4 kg for 30'' cylinders. In some facilities, the mass of non-volatile residues in cylinder could be estimated.

Reactivity increase due to uranium residues (UO_2F_2-(2x+y)H_2O) for an infinite array of cylinder





Depending of the mass and the moderation ratio, the presence of uranium residues in cylinders may increase the reactivity and has to be evaluated.

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