Corrosion and Pyrophoricity of ZPPR Fuel Plates: Implications for Basin Storage

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Summary

This paper presents the results of recent experimentation and analysis of the pyrophoric behavior of corroded Zero Power Physics Reactor (ZPPR) HEU fuel plates and the implications of these results for the handling, drying, and passivation of uranium metal fuels stored in water basins. The ZPPR plates are highly enriched uranium metal, approximately 2 x 2 x 1/16 inches in size, clad in thick stainless steel foil. The plates were originally clad in 1980; crevice corrosion of the uranium metal in a dry storage environment has occurred due to the use of porous cladding end plugs and possibly also residual moisture remaining after insufficient drying of the plates prior to cladding. The extensive corrosion has resulted in bulging and, in some cases, breaching of the cladding over a 15 year storage period. Recent placement of oxygen – water vapor getters in overpack containers for the plates has halted the corrosion process.

Processing of the plates has been initiated to recover the highly enriched uranium metal and remove the storage vulnerability identified with the corroded plates, which have been shown to contain significant quantities of the pyrophoric compound uranium hydride (UH₃). Experiments were undertaken to determine effective passivation techniques for the corrosion product; analysis and modeling was performed to determine whether heat generated by rapid hydride re-oxidation could ignite the underlying metal plates. The results of the initial passivation experiment showed that simple exposure of the hydride-containing corrosion product to an Ar – 3 vol.% O₂ environment was insufficient to fully passivate the hydride—"flare-up" of the product occurred during subsequent vigorous handling in air. A second experiment demonstrated that corrosion product was fully stable following grinding of the product to a fine powder in the Ar – 3 vol.% O₂ atmosphere. Numerical modeling of a corroded plate indicated that ignition of the plate due to the heat
from hydride re-oxidation was likely if hydride fractions in the corrosion product exceeded 30%.

Information generated in this series of experiments has important implications for basin storage of spent uranium metal fuels. First, the reactivity of products formed during crevice corrosion of uranium metal was clearly demonstrated. Although these products were formed during gaseous oxidation rather than aqueous, similar products are expected to form due to the crevice nature of the corrosion situation. The results also indicate that hydride-containing corrosion products can be safely handled in low oxygen concentration inert gas environments, and that simple exposure of the products to such an environment may not be sufficient for full passivation.