Corrosion Sensitivity of Stainless Steels in Pressurized Water Reactor Water Chemistry: Can KOH replace LiOH in PWRs?

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ABSTRACT:

The objective of this work is to determine if switching from LiOH to KOH to control the pH in nuclear reactors is possible without worsening the corrosion behavior of the structural alloys used in PWR core internal components. The impacts of such a change and the consequent water chemistry alterations on the corrosion processes and NPP core-internal component service-life will be assessed and better understood. For that matter, experimental testing will compare environmentally-assisted crack (EAC) initiation and growth rates of the same material under the same test parameters - in particular, the pH(T) of the environment, but using KOH versus LiOH. We will determine whether the cations K+ and Li+ influence the rates differently.

A series of corrosion and stress corrosion tests will be done on unirradiated alloys – including stainless steels and nickel-based alloys, with priority given to stainless steels. The effect of KOH vs LiOH will be evaluated as a function of alloy composition to establish if higher or lower alloyed materials exhibit different alkali susceptibility dependencies. Stainless steel 304 and 316L are indeed the most commonly used materials in PWRs and are the core materials to be studied. The effect of specific compositional differences and pre condition (cold worked vs. not cold worked) will be considered. The tests will be followed by post corrosion characterization with different techniques depending on the test: Weight change measurements and SEM/EDX will be performed as well as TEM characterization and chemical mapping to describe oxide layers chemistry and microstructure. These will be further complemented by select atom probe tomography measurements of the passive film composition, including quantification of the alkali species that are difficult to detect by electron beam techniques.

The effects of irradiated microstructures will be studied via proton irradiation, followed by testing in KOH and LiOH environments (including under stress). The team will investigate the effect of radiolysis with the use of in-situ high intensity gamma sources through a sapphire window of the autoclaves. These results will be compared with previously tested, neutron irradiated samples of 304 SS provided by EPRI.