Fatigue Aging Mechanisms of Reactor Structural Materials

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Background:

During reactor operation, flaws may form in components from which corrosion fatigue cracks may initiate. As advanced reactor concepts are developed all materials will have to demonstrate that they meet applicable fatigue standards. Currently there are limited fatigue data available on zirconium alloys.

Federal stakeholder: CNSC

Objective:

Characterize the effects of fatigue loading conditions and irradiation on the time to initiate a fatigue crack in zirconium alloys exposed to a water environment.

- Crack initiation in water was reduced by approximately a factor of 2 compared with air.
- A long rise time reduced the number of cycles to fatigue crack initiation.
- Implementing a 900s hold at the maximum load did not impact crack initiation.
- A ZrO_2 oxide is observed along the cracks for all specimens.
- The specimens tested in water exhibited a more blunt crack tip and more crack branching or secondary cracking within the oxide and along β-phase boundaries.
- For the pre-hydrided specimen tested in air, a narrow extension of oxygen is observed ahead of the crack tip
- The plastic zone is uniform and localized for the non-hydrided specimen tested in air.
- The plastic zone becomes less uniform and more randomly oriented in water environment or with hydrogen present

Expected outcomes:

- To obtain information to enable long-term projections of corrosion fatigue crack initiation in zirconium alloys.
- Peer reviewed paper on the effect of water environment on corrosion fatigue crack initiation.