Engineered composite patch with NDE inspection for repair and mitigation of SCC in nuclear spent fuel dry storage canister

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ABSTRACT:

Interim storage of spent nuclear fuel (SNF) from reactor sites has gained additional importance and urgency for resolving waste-management-related technical issues. For canisters located at independent spent fuel storage installations (ISFSI) near the coastal regions, chloride-bearing salts may deposit on the external surface of the canister. Under certain temperature and humidity conditions, the salt will deliquesce to form brines. With the welding residual stress (WRS) as the driving force, the CISCC would take place in the weldment and/or the heat affected zone (HAZ) in these canisters. SCC has been identified as a potential nuclear safety concern because of the possibility that through-wall penetration could breach the confinement/containment boundary of the canisters and release the radioactive materials. Research has been carried out worldwide to consider possible remediation actions. Various methods such as coating, friction stir processing, post-weld surface enhancement, sleeve repairs, or sequential buffing have been investigated or used.

In response to the urgent need for reliable repair and mitigation techniques of SCC in dry cask canisters, we propose to develop an "engineered composite patch" that can absorb moisture, and prevent SCC from further growth while providing nondestructive evaluation (NDE) inspection capability, without high-heat spark generation. The flexible composite patch equipped with corrosion inhibitor can be easily bonded to the surface of a welded or HAZ on the canister to absorb moisture in the SCC, while reducing the residual stress to prevent the crack from growing through-wall. To assure the patch installation quality and to monitor possible SCC growth after repair, an NDE capability will be integrated into the package. The NDE capability is enabled by the use of remote laser ultrasonic characterization methods and imaging based advanced diagnostic algorithms. It will evaluate the bond quality for patching-structure integrity and continue to monitor the crack growth and/or pits development. Overall, the patch will repair the cracks and mitigate the adverse condition on the SCC site to ensure that the canisters meet the confinement/containment requirements for long-term storage and transportation.

As dictated by the Aging Management Program (AMP), canister inspection, and thus repair/mitigation technologies must be ready to deploy should SCC be found. Internal SNF cladding integrity concerns and hydrogen gas generated from radiolysis require that the canister repair methods be low heat, low external mechanical load, and no sparks. The outcome of this project will be an effective and game-changing repair and mitigation method for SCC and pitting that can prevent the existing cracks or pits from further growing through the canister wall, and will provide an NDE inspection capability to ensure the patching quality and on-demand structural integrity evaluation.