

Transitioning Aluminum Clad Spent Fuels from Wet to Interim Dry Storage

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Introduction

The United States Department of Energy (DOE) currently owns several hundred metric tons of aluminum clad, spent nuclear fuel and target assemblies. The vast majority of these irradiated assemblies are currently stored in water basins that were designed and operated for short term fuel cooling prior to fuel reprocessing. Recent DOE decisions to severely limit the reprocessing option have significantly lengthened the time of storage, thus increasing the tendency for corrosion induced degradation of the fuel cladding and the underlying core material. The portent of continued corrosion, coupled with the age of existing wet storage facilities and the cost of continuing basin operations, including necessary upgrades to meet current facility standards, may force the DOE to transition these wet stored, aluminum clad spent fuels to interim dry storage. The facilities for interim dry storage have not been developed, partially because fuel storage requirements and specifications for acceptable fuel forms are lacking. In spite of the lack of both facilities and specifications, current plans are to dry store fuels for approximately 40 to 60 years or until firm decisions are developed for final fuel disposition.

The transition of the aluminum clad fuels from wet to interim dry storage will require a sequence of drying and canning operations which will include selected fuel preparations such as vacuum drying and conditioning of the storage atmosphere. Laboratory experiments and review of the available literature have demonstrated that successful interim dry storage may also require the use of fuel and canister cleaning or rinsing techniques that preclude, or at least minimize, the potential for the accumulation of chloride and other potentially deleterious ions in the dry storage environment.

This paper summarizes an evaluation of the impact of fuel transitioning techniques on the potential for corrosion induced degradation of fuel forms during interim dry storage.

Transitioning Process

Aluminum alloys typically have good corrosion resistance in natural atmospheres, fresh waters, sea water and soils (1). This resistance is derived from an adherent, protective or

barrier film which forms whenever the surface is exposed to air (oxygen) or water. Much of the understanding of aluminum behavior in corrosive environments is based on the chemistry of, and transport in, these barrier films. Anions may be incorporated in the film and influence corrosion by the formation of water soluble salts and/or changing the mobility of Al^{3+} or other ions in the film (2). Basically, the behavior of aluminum in corrosive environments is controlled by the chemistry of, and ion transport in, the barrier films. Anions, such as Cl^- and SO_4^{2-} , are frequently incorporated in the surface films as water soluble salts, for example $\text{Al}_2(\text{SO}_4)_3$. The protective character of the barrier film will decrease and the tendency for continued corrosion will increase whenever such salts and other "soft spots" are developed.

The water chemistry in many of the storage basins for the aluminum clad spent nuclear fuels has not precluded significant uptake of Cl^- , SO_4^{2-} and other potentially corrosion accelerating species (3). Thus, the exposure of the fuel to the wet storage environment may have caused "soft spots" to develop during wet storage which can compromise the protective character of the surface films and increase the susceptibility of the cladding to corrosion even after the fuel has been transitioned to interim dry storage. This observation suggests that the susceptibility of a fuel to corrosion during interim dry storage will depend on the effectiveness of the transitioning process in eliminating water soluble salts and "soft spots" from the barrier films.

Chloride and other potentially deleterious ions may also be brought into the dry storage environment with the container materials. Surface films on the stainless steel, aluminum alloys and other potential materials of construction for interim dry storage casks and canisters will contain adsorbed ions that could be transferred to, and degrade, protective film on the stored fuel cladding unless appropriate procedures are developed. This became apparent during autoclave testing to evaluate the potential for aluminum degradation during interim dry storage (4, 5).

The chloride content on the surface of aluminum coupons exposed in a stainless steel autoclave increased during exposure, even though atmospheric moisture condensate that had a low chloride ion concentration was used to control the humidity of the storage atmosphere. Pre- and post-exposure chemical analyses of the water and the surfaces of the aluminum coupons are consistent with concentration of the chloride ions in the remaining water as water is consumed in the growth of a hydrated oxide film, and with a transfer of chloride ions from surfaces of the stainless steel autoclave to the water.

Additionally, pits were observed on some of the exposed coupons after the chloride enrichment had developed. These experimental results indicate that the susceptibility of aluminum clad fuels to corrosion during interim dry storage may depend on the ability of canister cleaning techniques to remove deleterious ions from the exposed surfaces.

Conclusions

Ionic species can affect the corrosion behavior of aluminum in a dry storage environment. Processes of transitioning fuel from wet to interim dry storage should include:

- 1) techniques to remove deleterious ions (e.g., Cl^- and SO_4^{2-}) from surface of fuel and target elements, and
- 2) surface preparations that eliminate, or at least minimize, the presence of deleterious ions from the surfaces of materials of construction for dry storage casts.

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