The Reviewing FFA(Film Forming Amine) Application Technology for Reducing Corrosion of Secondary System composited of Materials during the Overhaul(OH)

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1. Introduction

Domestic nuclear power plants have an overhaul for replacement nuclear fuel and maintenance major system. Generally overhaul period is average 40~50 days. During the overhaul period, nuclear power plants make an effort to mitigate corrosion of materials following as steam generators are preserved using method of wet-layup and other of secondary system are preserved by control relative humidity less than 40%, respectively. Although these preservation methods are effective, they are difficult to completely prevent corrosion of materials during the overhaul. So then, corrosion product transport during startup into the steam generators.

Further, as noted in the PWR secondary water chemistry guidelines, corrosion products transported during startup are potentially more oxidizing than those transported during full power operation may increase the risk of material degradation to a greater degree than deposits transported during steady-state operation. So KHNP has continued to explore candidate options for further reducing these rate for susceptible components throughout the PWR secondary plant.

In this study, application ability of FFA (Film Forming Amine) to the secondary system overhaul period. To reviewing application possibility of FFA, following as FFA corrosion inhibition mechanisms and then brief overview FFA plant experience abroad. Finally, considering technical qualification for PWR secondary use of film-forming products and efficacy.

2. Methods and Results

2.1 Mechanisms for Corrosion Inhibition due to FA Exposure

FFA application technology is one simple hypothesis is that FAs are attracted to metal surfaces by the free electron pair on the nitrogen. The long carbon chains then protrude from the metal surface. This situation is shown schematically in Fig.1. Polyamines-i.e., FAs with more than one amine group (n>0)-form multiple connections with the metal/metal oxide surface which allows some of the FA structure to cover the surface horizontally. This is illustrated in Fig. 2. In this interpretation, the presence of multiple amine groups would be beneficial because it provides greater coverage of the surfaces.

Fig. 1. Illustration of Amine Adsorption onto Metal Surface

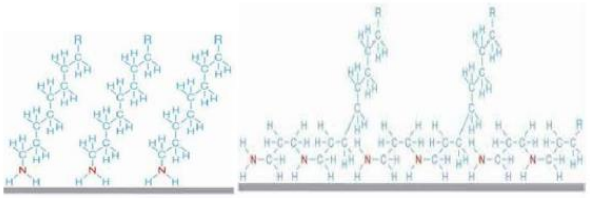

Fig. 2. Film Formation with Monoamines (left) and Polyamines (right)

2.2 Reviewing FFA Application to Plant Experience abroad

To date, only one FA-ODA- is known to have been used in nuclear power plants. The first of these applications (batched micro-additions) were carried out in three PWR power stations in Russia and Germany in the 1980s and 1990s. In the 2000s, a trial application of ODA was carried out at Kola Unit 2, a PWR unit in Russia. Subsequently, beginning in 2011, ODA in the form of ODACON f® has been applied a number of times by AREVA and the operating utilities at both Almaraz units in Spain and at Embalse in Argentina. And now in 2022, a number of FFA application nuclear power plants are 12 units (table 1).

Table I: The Statues of FFA application at Nuclear Power Plants in 2022

Year	Country	Unit	Reactor type
2011	Spain	Almaraz-1	PWR
2012		Almaraz-2	
2015	Argentina	Embalse	PHWR
2017	Netherlands	Borssele	PWR
2018	France	Blaysis-1	
2019	Canada	Bruce Power6	PHWR
2020		Darlington-3	
2021	Slovenia	Krsko	PWR
	South Africa	Koeberg	
	Canada	Bruce Power7	PHWR
2022	Canada	Bruce Power5,3	

2.3 Material Compatibility

It is expected that, in general, FFA will produce protective films that reduce corrosion rates. However, in order to qualify an FFA formulation for PWR secondary use, it will be necessary to demonstrate that unanticipated, unacceptable increase in the corrosion rate of the various plant materials that will be exposed to not occur across the plausible range of exposure conditions. AREVA performed laboratory testing to demonstrate the essential compatibility of ODACON® with a selection of secondary plant materials. The results about materials compatibility are as follows:

- To be following test about SG tubing integrity, it is expected that FFA exposure in prototypical conditions either has no effect on the tubing corrosion rate
- About SG internal components and feedwater, BOP components, it is expected that similar or more favorable results for FFA exposure in prototypical environments will be considered acceptable from a material compatibility standpoint
- About the other components, it is expected that there is no effect to the materials integrity problems.

2.4 Effect of FFA Application

In case of an FFA treatment using ODACON® to the Embalse Nuclear Power Station for minimize corrosion of secondary plant components during the lengthy layup, FA film was formatted on the surface of materials (fig.3)

Fig. 3. ODACON® Application for Layup at Embalse (FW Heater)

Reference reported that the sulfate concentrations were 1 ppb in the feewater and 15 ppb in the SG blowdown at the conclusion of the FFA addition period. None of the other chemistry parameters were reported.

Prior to the first Almaraz application in 2011, ODA was added to several PWRs with VVER SG designs. FFA applied result was apparent reductions in the corrosion rates for a number of secondary components.

3. Conclusions

Among the domestic nuclear power plants, A Plants is considering FFA application during the dry layup to the secondary system. For FFA application, KHNP CRI is reviewing the effect to the materials integrity, overseas nuclear power plant application cases and injection effects.

The reviewing results are following as:

-To date, only one FA-ODA- is known to have been used in nuclear power plants.
-From the point of view of materials integrity, there are no any negative impact.
-When FFA is applied to the secondary system for the dry layup, it is one of methods to reduce corrosion products.
- But for application FFA, it is important that injection location and injection time.

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