

The Assessment of Integrity of SG Component Materials and Iron Oxide Removal Amount in the Chemical Cleaning Environments with 1.3% EDTA Agent

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1. Introduction

During the normal operation of the nuclear power plants, secondary system component materials corrode due to accelerated flow, which then get into the steam generators. While some of the corrosion products entering the steam generator (here after, SG) are removed through the blowdown system, most of them are deposited and accumulated internally. These deposited corrosion products can cause SCC (stress corrosion cracking) in tubes [1] or block the flow path, leading to water level oscillation. To solve these problems, nuclear power plants periodically remove these corrosion products through chemical cleaning. EDTA (Ethylene Diamine Tetra Acetic Acid, here after EDTA) chemicals used in chemical cleaning react with corrosion products, but they also react with SG components to cause corrosion, so the material integrity must be verified in advance. This study, as part of a chemical cleaning qualification test, evaluated the integrity of SG components and the amount of corrosion products removed in a 1.3% EDTA chemical cleaning environment.

2. Methods

For evaluation purposes, equipment capable of simulating a chemical cleaning, environment was manufactured and utilized. Furthermore, real-time corrosion rate measurement equipment was installed to monitor transient corrosion that may occur during chemical cleaning experiments.

2.1. Specimen types and sizes

The SG is made of various carbon steel materials, excluding the tubes and tube support plate. Six types (A508, A105, A285, A106, A36, A516) of carbon steel were used in the tests. The corrosion rate for each type of carbon steel was designed to enable the evaluation of general corrosion and galvanic corrosion. The surface area of the carbon steel specimens was manufactured to consider the ratio of the volume of chemical cleaning agent in contact with the material surface. This ratio is 47 cm²/L.

2.2. Loading amount of Corrosion Products

The loading amount was calculated to evaluate the amount of corrosion products removed through the qualification test. The corrosion products used were collected from the SG of the target nuclear power plant.

To calculate the loading amount, data on iron concentration in the feedwater and the iron concentration in the blowdown system were referenced at the target plant. The amount of corrosion products accumulated in the SG calculated was 1,036 kg/SG. This calculated amount, when converted to a laboratory scale, equals 38 g/L.

2.3. Process & Conditions and Assessment Methods

The chemical cleaning process consists of two iron removal steps and three washing steps. The first iron removal step lasts 24 hours, and the second iron removal step, which involves the addition of EDTA (1.3%) as a cleaning agent, lasts 24 hours. The cleaning temperature is 82°C, and the cleaning agent is 1.3% EDTA, 0.1% hydrazine, and the pH is controlled to 9.0 using ammonia. Material integrity was assessed using the weight loss of specimens before and after the experiment to determine whether the corrosion rate was within the allowable range and whether localized corrosion on the surface was present. The amount of corrosion product removed was measured by sampling every two hours and analyzing the iron concentration using an ICP-OES device. The final removal amount was then assessed using the analysis results.

3. Results and Conclusion

As a result of the corrosion rate evaluation, the average corrosion rate of the specimens with general corrosion was calculated to be 0.55 mils, and the average corrosion rate of the specimens with galvanic corrosion was 1.45 mils. Regardless of the type of carbon steel specimen, all specimens satisfied the corrosion allowance (< 2 mils). Surface analysis of the specimens revealed no evidence of localized corrosion. These results suggest that the 1.3% EDTA chemical cleaning environment has no effect on the integrity of SG components. After the experiment, the amount of iron oxide removed was calculated to be approximately 25 g, which is 13% of the initial iron oxide loading. Using this result, the amount of iron oxide removed in the target power plant SG is predicted to be approximately 545 kg.

REFERENCES

- [1] *Steam Generator Management Program: PWR Steam Generator Top-of-Tubesheet Denting*: History and Gauses. EPRI, Palo Alto, CA:2014. 3002002197.