# The Necessity Review adding Fluoride Parameter in Steam Generator and Feedwater for Managing Component Integrity at NPP

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#### 1. Introduction

A nuclear power plant was safety inspected by WANO (World Association of Nuclear Operators) Peer Review. Peer Review results suggested that fluoride parameter should be added to the monitoring parameters at Steam Generators and Feedwater System in the operating procedures. Accordingly, the Central Research Institute (after that, called CRI) provided technical support regarding the need to add fluoride parameter in Steam Generators and Feedwater. For this purpose, a literature review was first conducted. A total of four articles were reviewed, one of which was the EPRI (Electric Power Research Institute) report (Pressurized Water Reactor Secondary Water Chemistry Guidelines) and the others were published or presented papers at conference. EPRI report was reviewed because the operation (water quality management) procedures of the A nuclear power plant was written based on the EPRI Pressurized Water Reactor Secondary Water Chemistry Guidelines. In EPRI report, the modes are classified into shutdown, heatup, and power operation depending on the physical and chemical state of the water inside the steam generator. This report selects chemical parameters for each mode and describes their technical background. However, the scope of this review only covers the power operation mode, not the chemical parameters described for all modes. Next, the experimental results cited in the literature were used to evaluate the effects on the components of the A nuclear power plant. Based on a comprehensive review of the literature and the results of the review on the effects of fluoride on the components of A nuclear power plant and then a decision was made on the need to monitoring fluoride parameter in the Steam Generator and Feedwater system in the operating procedures.

#### 2. Results & Discussion

### 2.1. EPRI Report Review

The EPRI guidelines have been revised eight times since that was published in 1982, up until 2017. In the first edition, fluoride was not listed as monitoring items for Steam Generators and Feedwater system. The reason for this appears to be that there was no experience or experimental data regarding fluoride as a cause of corrosion of steam generator tubes and turbine materials. Fluoride was mentioned in the first revision. However, it was not mentioned because of its effect on material integrity. It was simply because fluoride was the contributing factor when the measured cation conductivity values and the values obtained using analytical equipment did not match [1]. In the fourth revision, it was stated for the first time that fluoride can affect the corrosion of system components. The 6<sup>th</sup> revision specifically states that fluoride can affect the IGSCC (Intergranular Stress Corrosion Cracking) of austenitic stainless steels. Reference to experimental tests are cited as the basis for this judgement. However, the last sentence states that there is no experimental data or experience of material corrosion due to fluoride in pressurized water reactors [2].

#### 2.2. Review of the Effects of Fluoride on A Plant Components

Published and presented papers show that austenitic stainless steels are the cause of accelerated IGSCC by fluoride. According to the content published in the paper, a CERT (Constant Elongation Rate Tensile) experiment was conducted using specimens made of austenitic stainlesssteel material under supercritical experimental conditions (Normal Water Chemistry and Hydrogen Water Chemistry). The experimental results showed that the stress corrosion cracking growth rate increased due to fluoride (fig. 1).



Fig. 1. Average crack propagation rate measurement results in normal water chemistry (left) and hydrogen water chemistry (right) environments [3]

To evaluate whether fluoride affects the integrity of A plant components, the secondary system components of A plant were investigated (table 1). It was found that the main materials of the secondary system of A plant are nickel alloy, carbon steel, low carbon steel, and Cr-Mo alloy. The steam generator tube support plate material was investigated to be stainless steel. However, this material is martensitic stainless steel, which has a different microstructure from austenitic stainless steel. In conclusion,

it appears that the components of A plant will not be corrode by fluoride.

Table 1: The component	materials	of	secondary	system	at	А
nuclear power plant						

Component	Component Parts		Remark	
Steam Generators	Tubes	Ni-Alloy		
	Tube Sheet	Low CS		
	Support Plates	SS	Martensitic	
	Housing	Low CS		
Condenser	Tubes	Ti-Alloy		
	Housing	CS		
Low/High Pressure Heater	Tubes	SS(LPH), CS(HPH)		
	Shell	CS		
HP/LP Turbines	Blade	Cr-Mo Alloy	LPT Stationary Blades: Cast Iron	
	Rotor	Cr-Mo Alloy		
	Housing	Cast Iron (HPT), Cr-MoAlloy(LPT)		
	Diaphragm	Cr-Mo Alloy		
Piping	Main Steam	CS		
	Main Feed	CS		
	Blowdown	Cr-Mo Alloy		

## 3. Conclusion & Future works

A plant was recommended to monitor fluoride in Steam Generators and Feedwater as a result of the WANO Peer Review. With technical support, the CRI reviewed the need for addition fluoride parameter according to the proposal. In nuclear power plants, monitoring parameters are selected for chemical species that affect the integrity of the constituent materials. For this reason, the EPRI report (Pressurized Water Reactor Secondary Water Chemistry Guidelines) and related published papers were reviewed. Next, CRI reviewed the data (published papers) about the impact of fluoride on material integrity, and conducted an evaluation of the effect to components of A plant based on the experimental results in published papers.

The EPRI report and published papers showed that fluoride accelerates IGSCC in austenitic stainless steel. And a survey of A plant components found that the tube support plates were made of stainless steel, but were found to be martensitic stainless steel with a different crystal structure from austenitic stainless steel. Additionally, martensitic stainless steels have been reported to experience corrosion by fluoride in pressurized water reactor operating environments or have been experimentally tested to data. Based on the review results, it appears that fluoride parameter monitoring is not necessary in the Steam Generator and Feedwater system. However, we cannot be sure that fluoride will not have any effect on component materials of secondary system just because there has been no experience or experiment test with it yet. Therefore, A plant must continuously monitor related literature and experimental data and consider whether to add fluoride parameter based on this.

#### REFERENCES

[1] Pressurized Water Reactor Secondary Water Chemistry Guilelines.rev.1., EPRI, Palo Alto, CA: 1984. NP-5056-SR.

[2] Pressurized Water Reactor Secondary Water Chemistry Guilelines.rev.8., EPRI, Palo Alto, CA: 2017. 3002010645.

[3] L.G.Ljungberg, et al., Effects of Some Seldom Noticed Water Impurities on Stress Corrosion Cracking of BWR Construction Materials, Corrosion, Vol 45, No3., March 1989.