Effect of Cr content on flow-accelerated corrosion rate and its correlation with oxide layer characteristics

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Flow accelerated corrosion (FAC) is widely known to be one of the primary cause of pipe wall thinning in nuclear power plants. The FAC rate is strongly affected by the Cr content in steel, and even a small impurity level of Cr in steel suppresses FAC under the conditions where magnetite forms. However, the mechanistic relationship between the Cr content and FAC rate is not fully understood.

In this study, effect of Cr content on FAC rate was investigated by the corrosion experiments under flow. The detailed characterization of the oxide layer formed on a carbon steel under an FAC condition was carried out to reveal the nano-void structure, thickness, and Cr enrichment. The mechanism of FAC suppression by trace Cr was also discussed based on the relationship between above characteristics and the FAC rate. The threshold Cr content for Cr enrichment in the oxide layer in this study seemed to be around 0.04%, which was equal to the well-known “threshold” Cr content. The Cr enrichment in the oxide film might have been due to the preferential dissolution of iron in the Fe-Cr spinel oxide, which is known to be less soluble in high-temperature water than magnetite. This finding indicated that the Fe-Cr spinel oxide formation reduced the FAC rate because of its low solubility. On the other hand, it indicated the possibility of enhancing the detachment susceptibility of the oxide by the mechanical effect of a turbulent water flow.