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Flow accelerated corrosion: Experience from examination of components from nuclear power plants

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ABSTRACT

Flow accelerated corrosion (FAC) has affected a large number of components made from carbon steel in the secondary as well as primary circuits of light water reactors worldwide. This is primarily a corrosion process enhanced by (electro) chemical dissolution and mass transfer, rather than a mechanical process. It has caused rupture of all sizes of pipelines as well as other components carrying either single phase water or two phase (wet steam) flow. It is reported to be the only mechanism that has significant potential for large leaks in the secondary circuit. This paper describes the observations from examination of a number of components that were affected by FAC in Pressurized Heavy Water Reactors in the past 5 years. Failure analysis done on the 10% feed water line, non-return valve (NRV) in the auxiliary feed water system and on the affected pipeline components from the secondary water system of various reactors has been described in this paper. The surface features observed (the signature pattern of FAC) on the inner surfaces of the pipelines affected by FAC in the primary and the secondary circuits of nuclear reactors have been described. Signature patterns of FAC, on components severely affected by single phase FAC (scallops) and on components affected by dual phase FAC (tiger striping) are recorded and reported. Components where FAC degradation had just initiated showed that the patterns were not well defined. The signature patterns became evident only after the degradation had occurred to a large extent. FAC like features were not seen in stainless steel components in the secondary side. Case studies showing that thinning of carbon steel components is not always attributable to FAC in the secondary circuit of the reactors are also described and reasons of these thinning illustrated to show the importance of establishing the cause of each thinning case. The paper also discusses if the size of the scallops is possible to be correlated to the FAC rate.

1. Introduction

Flow accelerated corrosion (FAC) causes wall thinning (metal thickness loss) of carbon steel piping, tubing and vessels exposed to flowing water or wet steam. When the thickness of the component reaches values lower than the critical thickness required for supporting the operating stresses, it results in ductile failure of the component. If undetected, the degraded components can suddenly rupture, releasing high temperature steam or water. FAC has caused a large number of failures in piping and equipments in all types of fossil, industrial steam, and nuclear power plants and it is a predominant mode of failure of pipelines in the secondary circuit and has also affected carbon steel pipelines in the primary circuit of light water reactors (LWR) [1–8].

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