Divider Plate Cracking in Steam Generators

Results of Phase 1: Analysis of Primary Water Stress Corrosion Cracking and Mechanical Fatigue in the Alloy 600 Stub Runner to Divider Plate Weld Material

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PRODUCT DESCRIPTION

Cracking in steam generator divider plate to stub runner welds has been reported by Electricité de France (EdF) plants. This report describes a conservative detailed analysis of a crack in the divider plate to stub runner weld of a domestic Westinghouse-designed steam generator. The crack growth analysis considers the effects of both mechanical fatigue and primary water stress corrosion cracking (PWSCC). There are no reports of divider plate cracking in the domestic market. The goal of this report is to determine if divider plate cracking is a concern for domestic nuclear power plants with Westinghouse steam generators.

Results and Findings

This report provides a conservative crack and fatigue life estimate analysis. Results show that currently observed cracks in the foreign steam generators are not capable of causing the divider plate to fail in the worst-case domestic steam generator during accident or normal operating conditions. However, it is possible for cracks in the divider plate to increase in both length and depth once they have initiated in the divider plate to stub runner weld. Vertical tubesheet displacement will increase by more than 2% for a crack greater than 64% into the depth of the divider plate for all operational conditions.

Challenges and Objectives

This report is intended for steam generator analysts and engineers in nuclear power. This report is mainly applicable to nuclear power plants that have Westinghouse-designed steam generators, without center stays or floating divider plates. The purpose of this report is to establish if divider plate cracking indications reported in foreign steam generators are a concern for the domestic steam generator fleet. Specifically, the purpose of the analysis is to determine

- the limiting case model of steam generators with respect to divider plate cracking,
- if a crack in the divider plate can increase vertical tubesheet displacements by more than 2%., and
- if a crack in the divider plate can propagate 100% through the weld material.

Applications, Values, and Use

The results in this report will form the basis for future analyses that will mitigate or eliminate the need for divider plate inspections. The details listed herein will also be useful for steam generator engineers to use in writing degradation assessments for future steam generator outage work.

EPRI Perspective

This report is first of a kind. To date there is no other available analysis on the effect of divider plate cracking in Westinghouse steam generators.

Approach

The project team used finite element methods and a first principles engineering mechanics evaluation to determine the effect of a divider plate on the steam generator.

Keywords

Divider Plate
Tubesheet Displacement
Mechanical Fatigue
PWSCC

ABSTRACT

Experience with foreign steam generators suggests that there is a possibility cracks may develop in the divider plate of non-center stayed steam generators due to the presence of Alloy 600 in the stub runner weld material and divider plate.

Current operating experience suggests that the cracks are due to material defects, weld defects, damage due to loose parts in the channel head and Primary Water Stress Corrosion Cracking (PWSCC). The cracks tend to occur in the heat affected zone of the stub runner to divider plate weld and have been observed to run nearly the length of the divider plate (~ 6 feet). As the cracks approach the triple point of the tubesheet-channel head (TS-CH) complex (the junction between the channel head, divider plate and tubesheet) the cracks begin to curve upwards. Current operating experience and non-destructive evaluation of steam generators that have developed these cracks indicates that the cracks remain shallow, in many cases less than 0.10 inch depth, and do not grow deeply into the divider plate.

However, the concern remains as to what effect a crack in the divider plate will have on the structural integrity of the lower steam generator complex. It is also important to develop a basis for understanding any crack propagation mechanism to predict the possibility of a crack running through the thickness of the divider plate if cracks do develop.

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There have been several documented cases of cracks and crack indications in the stub runner to divider plate weld in steam generators in operation outside of the United States [1, 2, 3, 4, 5].

The function of the divider plate in most Westinghouse steam generators is to provide a separation between the cold and hot legs of the channelhead as the primary water enters the steam generator. The divider plate is not considered a primary pressure boundary [6] in the context of this analysis. In most Model F, Model D and Model 51 steam generators the divider plate is also not considered a structural component of the lower steam generator complex.

In most Model F, Model D and Model 51 Westinghouse pressurized water reactor (PWR) steam generators the divider plate is initially welded to the channelhead and then attached to the tubesheet via a weld to a strip of metal on the primary side of the tubesheet called the stub runner. The weld between the stub runner and the divider plate is subject to bending and tension during regular operation of the steam generator. The tension on the divider plate occurs as the tubesheet bows from the difference between the primary and secondary operating pressures. The bending on the divider plate occurs because there is typically a temperature and a pressure difference between the hot leg and cold leg side of the tubesheet and divider plate [7]. The weld that connects the stub runner and the divider plate in some steam generators consists of Alloy 600 material. This metal is susceptible to primary water stress corrosion cracking (PWSCC).

The purpose of this report is to determine:

- The limiting case model of steam generator with respect to divider plate cracking.
- If a crack in the divider plate can increase vertical tubesheet displacements by more than 2%.
- If a crack in the divider plate can propagate 100% through the weld material.

Cracking in the divider plate is a concern because it affects tubesheet displacements. Tubesheet displacements may directly affect multiple regions in the SG that include such areas as:

- Stresses in the tubesheet-channelhead complex and connections
- Tube stress
- Plug retention/acceptability issues.

The results of the analysis do not specifically include details of divider plate cracking in designs without a stub runner. Cracking in the divider plate to channelhead weld connection is not examined. The effect that any stress increase in the lower steam generator complex due to divider plate degradation may cause is not examined.

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