History of Westinghouse Model 44 Steam Generators

Plants	Commercial Operation Dates	Replacement Dates
Ginna	07/1970	06/1996
Point Beach 1	12/1970	03/1983
H. B. Robinson	03/1971	10/1984
Point Beach 2	10/1972	12/1996
Turkey Point 3	12/1972	04/1982
Turkey Point 4	09/1973	05/1983
Indian Point 2	08/1974	N/A
Indian Point 3	08/1976	06/1989

Degradation Mechanisms in Westinghouse Model 44 Steam Generators

Model 44 Steam Generators (SGs) use alloy 600 material for tubing. The tubes are supported vertically by the thick tube sheet at the bottom of the steam generator and laterally by drilled-hole tube support plates which are made of carbon steel. Corrosive products (typically magnetite) tend to accumulate in the crevice between tube and tube support plates because of the drilled-hole configuration and the susceptibility of the carbon steel to corrosion. The corrosive products have caused tube denting which resulted in axially and circumferentially oriented stress corrosion cracking in tubes. This degradation mechanism was the predominant reason for tube plugging in model 44 SGs.

The tubes in Model 44 SGs were mechanically rolled for only a few inches into the tubesheet starting at the primary (lower) face of the tubesheet. As a result, a crevice exists between the tube and the tubesheet for the portion of the tube within the tubesheet that is not expanded. Since the tube was mechanically rolled into the tubesheet, the expansion transition is commonly referred to as a roll transition. Plants with SG tubes that are only roll expanded for a small distance within the tubesheet are referred to as partial-depth hardroll plants. The crevice region has been a site for corrosion. Degradation in the crevice and/or at the roll transition has led some plants to re-roll the tubes above the original rolled region to provide a new pressure boundary free of any detectable defects. By so doing, the licensees have been able to apply alternate repair criteria, such as the F-star criterion, in which tubes with degradation in a certain specified distance below the top of the tubesheet or the bottom of the roll transition (whichever is lower), may remain in service. Tubes accepted for continued service on the basis of the F-star criterion have structural and leakage integrity consistent with regulatory criteria.

In general, plants with SGs that have only been partially expanded into the tubesheet have exhibited very little circumferentially oriented degradation either at the expansion transition or at the top of the tubesheet.

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Most of these plants have exhibited axially oriented primary water stress corrosion cracking at the roll transition, axially oriented outside diameter stress corrosion cracking in the tubesheet crevice region, and/or intergranular attack in the tubesheet crevice region.

The small u-bend regions of the tubes have exhibited axial and circumferential cracking. The degradation is caused by excess ovality during tube fabrication process, residual stresses, and tube denting at the top tube support plate. However, some plants had preventively plugged the row of tubes with the smallest u-bends (innermost row).

There were wastage problems in early operation of model 44 SGs (see tube rupture events below). With improved secondary side chemistry, the tube wastage problem was essentially eliminated.

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