Effects of Chemistry Parameters of Primary Water affecting Leakage of Steam Generator Tube Cracks

D.M. Shin [a*], N.C. Cho [a], Y.S. Kang[a], K.H. Lee[a]
[a]*NDE Engr. Group, KHNP Central Research Institute., 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 314101*
[*]*Corresponding author: dmshin92@khnp.co.kr*

1. Introduction

Degradation of steam generator (SG) tubes can affect pressure boundary tightness. As a defense-in-depth measure, primary to secondary leak monitoring program for steam generators is implemented, and operation is allowed under leakage limits in nuclear power plants.

Chemistry parameters that affect steam generator tube leakage due to primary water stress corrosion cracking (PWSCC) are investigated in this study. Steam generator tubes investigated had experienced small leak due to PWSCC at the roll transition regions in tube sheets. Tube sleeves were installed to inhibit leakage and improve tube integrity as a part of maintenance methods. Steam generators occurred small leak during operation have been replaced with new steam generators according to plant maintenance strategies.

The correlations between steam generator leakage and chemistry parameters are presented.

2. Methods and Results

Chemistry parameters, dissolved hydrogen and reactor coolant pH_T, were controlled to reduce leak rate during normal operation when leakage of steam generator was indentified. N-16 radiation monitor measured leak rates of steam generator.

2.1 Dissolved Hydrogen effect on Leakage of PWSCC

Laboratory data indicate dissolved hydrogen concentration of reactor coolant can affect propagation of PWSCC. It is well known the upper part of the 25 cc/kg.H_2O to 50 cc/kg.H_2O dissolved hydrogen concentration can reduce PWSCC crack propagation [1].

In 1999, Steam generator A experienced small leakage under administrative leak rate limits. To reduce increasing leak rate, dissolved hydrogen concentration was raised from 30 cc/kg.H_2O to 45 cc/kg.H_2O. Dissolve hydrogen concentration and leak rates were measured by the on line monitors. Figure 1 shows there are no correlations between dissolved hydrogen and leak rates.

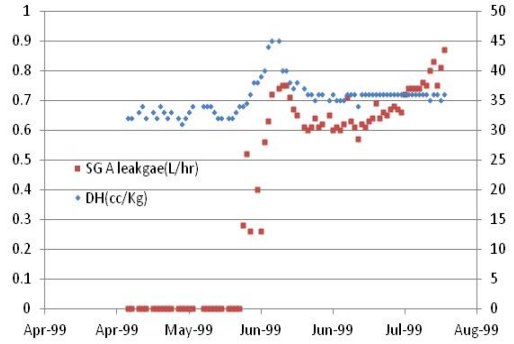

Fig. 1. Dissolved hydrogen increase test for the steam generator experiencing small leak

2.2 Reactor Coolant pH_T effect on Leakage of PWSCC

It was reported that some of nuclear power plants in Europe experienced leak rate changes from stress corrosion cracking of steam generator tubes resulted from reactor coolant pH_T changes [2]. It has been known that low pH(t) can reduce leak rate from SCC cracks without affecting crack size.

Unit A adopted modified primary water chemistry regime, which defines pH control in which the lithium is maintained as constant value during most of cycle operation until the end of cycle. It allows the pH to increase while boron concentration decreases.

Unit A experienced small leak from PWSCC cracks of steam generator in the end of cycle. Unit A shut downed several times due to other operation issues before small leak event in the same operation cycle. We thought operation transients caused loosening sleeving tightness between sleeves and parent tubes, thereby making leakage paths between primary to secondary side, and solubility increase of oxides due to high pH_T of the end of cycle contributed small leak.

In order to reduce leak rate, pH was controlled by servicing the delithiating bed operation within allowable pH_T control band. Leak rates were monitored with N-16 radiation monitors, and pH_T was calculated by pH calculation code.

Figure 2 shows leak rate was reduced as pH decreased. Leak rate decreased by about a factor of three in comparison with that of first observation leak.

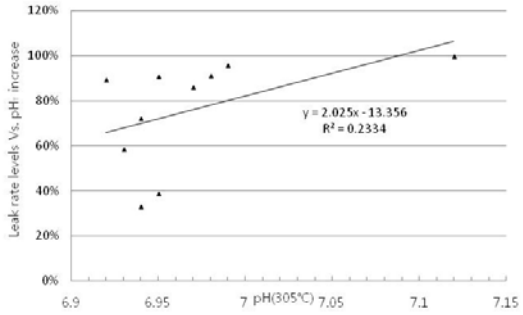

Fig. 2. Leak rate as a function of pH_T, Unit A

3. Conclusions

Effects of primary water chemistry parameters on leakage from tube cracks were investigated for the steam generators experiencing small leak.

Unit A experienced small leakage from steam generator tubes in the end of operation cycle. It was concluded that increased solubility of oxides due to high pH_T could make leakage paths, and low boron concentration lead to less blockage in cracks.

Increased dissolved hydrogen may retard crack propagations, but it did not reduce leak rate of the leaking steam generator.

In order to inhibit and reduce leakage, pH_T was controlled by servicing cation bed operation. The test results of decreasing pH_T indicate low pH_T can reduce leak rate of PWSCC cracks in the end of cycle.

REFERENCES

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[2] H. Feldman, D. Perkins, Steam Generator Management Program: PWR Primary-to-Secondary Leak Guidelines-Revision 4, 1022832, p.A-1, 2011.