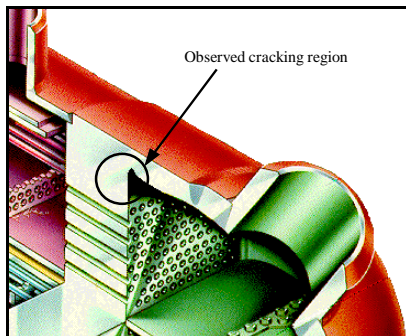


## Tube Sheet Cracking of High Pressure Feedwater Heaters

### BACKGROUND

High pressure feedwater heaters at fossil power plants can experience cracking in the transition region of the tube-sheet area (*Fig. 1*). A major power plant hired MIS to evaluate the integrity of their heaters, which had tube-sheet cracking, and identify the need for any corrective actions.



### DISCUSSION

During a routine inspection of high pressure feedwater heaters at a major power plant extensive cracking was detected at the transition region of the tube-sheet area. The original evaluation of these heaters attributed this cracking to thermal fatigue. A later inspection revealed an increase in the number and depth of the cracks since the previous inspection.

Using the geometry, material properties, and actual operating conditions of the heater, MIS developed detailed finite element models of the feedwater heater and performed stress and fracture mechanics analyses of the tube-sheet area (*Fig. 2*). Cracks of varying depths were modeled and their stress intensity factors were calculated (*Fig. 3*) and compared to the material's fracture toughness.

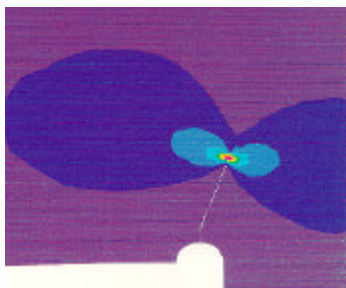


Figure 2. Stress contour of HP feedwater heater with cracking

The effect of operational changes, such as low load, on the integrity of the feedwater heaters was also evaluated.

This work confirmed that the cracking was due to thermal fatigue

caused by high stresses during load change. Pressure loading was found to significantly affect the initiation and growth of cracks. Furthermore, this study demonstrated that these cracks pose no immediate concern for reliability and safety of the heaters.

### CONCLUSION

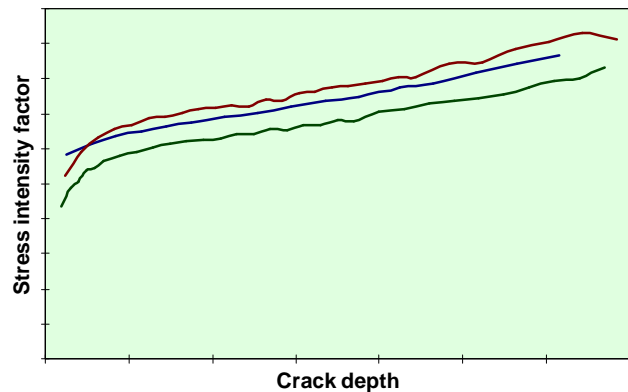


Figure 3.  $K_I$  vs.  $a$  for 3 different loadings

This study concluded the following:

- The feedwater tube-sheet cracking was the result of thermal fatigue.
- The high pressure feedwater heaters studied were of no immediate concern under normal operating conditions.
- Although thermal shock events, such as low-load operation, cause crack initiation and subsequent growth, pressure stresses profoundly affect both the initiation and growth rate of these cracks.
- The crack will not arrest due to very high operating stresses. However, it is estimated that a crack will reach its critical size after approximately 21 years based on the operating characteristics of this unit.

It was recommended that these heaters be inspected and the crack size measured at 7- to 8- year intervals.