ATTACHMENT 2

Errata pages for WCAP-13699, Rev. 2, Addendum 1

Non-Proprietary

3.3 Fatigue Analysis

In the laser welded sleeve (LWS) repair of steam generator tubes, the Alloy 690 sleeve is hydraulically expanded against the host Alloy 600 tube and a laser inside the sleeve is used to autogenously fuse the Alloy 690 sleeve and Alloy 600 tube over the full 360° circumference. The evaluation presented in this section demonstrates that the current minimum required laser weld axial engagement (fused) length of 0.015 inch satisfies the fatigue requirement of the ASME Code, Reference (1), with respect to the specified generic cyclic loads given in Reference (2). The ASME Code fatigue requirement is given in Section 2.3. The evaluation considers the following sleeve types for installation in Westinghouse steam generators with 3/4 inch OD x 0.043 inch wall host tubes and ABB-CE steam generators with 3/4 inch OD x 0.048 inch wall host tubes:

Full Length Tubesheet Sleeve (FLTS),

Elevated Tubesheet Sleeve (ETS),

Tube Support Plate Sleeve (TSS).

For each of the above sleeve types, the fatigue evaluation considers all possible combinations of [

]^{a,c}

3.3.1 Geometry and Materials

The weld is located at approximately the center of the 2.5 inch hydraulically expanded length of sleeve. The residual stresses due to the hydraulic expansion and the laser welding process are removed by heat treatment prior to returning the sleeved tube to service. Therefore, it is reasonable to assume that the strength properties (including the S-N fatigue curves) of Alloy 690 in the ASME Code also apply to the weld.

Geometry

The fatigue evaluation of the laser weld considers the following sleeve types:

Full Length Tubesheet Sleeve (FLTS), 36 inch length,

Elevated Tubesheet Sleeve (ETS), 12 inch length,

Tube Support Plate Sleeve (TSS), 12 inch length for 3/4 Westinghouse Host Tubes.

Tube Support Plate Sleeve (TSS), 15 inch length for 3/4 ABB-CE Host Tubes .

All hydraulic expansion lengths are assumed to be 2.5 inches with 0.25 inch long transitions at each end. Most geometric parameters are assumed to be at their nominal values, except that the minimum weld engagement length of 0.015 inch is assumed for all laser welds. The nominal outer diameter and wall thickness of the sleeve and tube are:

Westinghouse 3/4 Host Tube: 0.750 inch OD x 0.043 inch wall,

Sleeve: [ ]^{a,c} inch wall.

ABB-CE 3/4 Host Tube: 0.750 inch OD x 0.048 inch wall,

Sleeve: [ ]^{a,c} inch wall.

Material Data

The following material properties, taken from the ASME Code, Reference (1), are used in the fatigue evaluation:

Alloy 600 Tubes at 550°F

E = elastic modulus = 28.85×10^6 psi

μ = Poisson's ratio = 0.3

α = mean coefficient of thermal expansion from 70°F = 7.77×10^{-6} (°F)$^{-1}$

K = thermal conductivity = 2.57×10^{-4} BTU / (sec-in-°F)

Alloy 690 Sleeve at 600°F

E = elastic modulus = 27.8×10^6 psi

μ = Poisson's ratio = 0.3

α = mean coefficient of thermal expansion from 70°F = 8.16×10^{-6} (°F)$^{-1}$

K = thermal conductivity = 2.31×10^{-4} BTU / (sec-in-°F)

SA-508 Class 2 or 2a Tubesheet at 600°F

E = elastic modulus = 26.4×10^6 psi

μ = Poisson's ratio = 0.3

α = mean coefficient of thermal expansion from 70°F = 7.42×10^{-6} (°F)$^{-1}$

Air at 600°F (assumed in the gap between the unexpanded sleeve and host tube)

K = thermal conductivity = 5.78×10^{-7} BTU / (sec-in-°F)

3.3.2 Cyclic Load Conditions

The cyclic loads used in this evaluation are defined in the generic laser welded sleeve (LWS) design specification for the 3/4 inch OD host tubes, Reference (2). The normal, upset, and test transients are generally given in terms of transient changes relative to an initial steady state condition, usually at full power operation. The full power conditions, which are assumed in the generic LWS fatigue evaluation, are listed below: