(20)

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Subject: Davis Bessie Report

Comments:

We don't not have any residual stress distributions except for Riccardella's so I have to do back inferences instead of trying to directly check their results. I also have to make some guesses about how they did their analyses, ie., what values they used for the parameter A in the Scott CGR model.

Page 15 deterministic analysis.

There is a deterministic analysis of the growth of a circ crack on page 15. It assumes you get a J groove crack, quickly initiate a long circ crack 165 by multiple initiation. Then it takes 3.5 years to grow throughwall, 4 years to grow another 25%. Since the crack seems unlikely to slow down at this point, we can assume it grows to failure in 4 more years. Thus we have 11.5 years from the initiation of the OD crack to failure.

This is based on the B&W residual stresses and a "Peter Scott" crack growth law. Since this analysis is based on BAW-10190 May 1993, I assume they use the value of the Scott parameter A corresponding to that quoted in that report: 2.23 x 10^-12 (325C). This is a very low estimate of the 95th percentile curve for Alloy 600. It is low by factor of at least 3 and by as much as 8 (my best estimate). Using my value for the Scott A I get 11.5/8=1.43 years=17 months to failure from initiation of the 165 OD crack. They must have higher stresses than I get from Riccardella, because when I use K_ric and a 95th percentile curve I get 44 months for the throughwall growth to failure alone.

The B&W calculation with my adjustment for the 95th percentile suggests that for a throughwall 165 crack, failure occurs in (4+4)/8 years=12 months at the 95 confidence level. Assuming that we only want to consider the portion of the CGR distribution above the 50th percentile, this says that the the time to reach a conditional POF of 0.1 is 12 months. For failure in 18 and 20 months, A can decrease by a factor of 18/12 and 24/12, 1.5 and 2.0. This increases the proportion of the population that can fail. Based on my estimate of the population this now includes the 90th and 84th percentiles, implying the conditional POF for 18 months is 0.2 and for 24 months 0.36. If we assume conservatively that the probability of having a 165 crack at the last inspection is 1, then the POF is 0.2*POD and 0.36*POD for 18 and 24 months respectively where POD is the probability that the visual inspection will detect the crack. With a POD of 0.05, you find that 18 months is just about right to stay at a POF of 0.01. At 24 months the POF is 0.02. Things of course improve dramatically if you only increase their CGRs by a factor of 3 rather than 8. Additionally if we assume the probability of having the throughwall 165 crack is <1, then the POFs also decrease proportionately.

Page 16

I am glad to see they finally admit that leakage will probably get plugged. Maybe

B-56

thermal cycling will keep it open and maybe it won't.

Page 26

I agree with the argument that the boron crystals on the top of the head occur coincident with the formation of the environment conducive to cracking. I am not so confident that you will always get boron crystals when the initial leak occurs.

pg 28

They assume POD of missing a leak is 0.06 at first inspection and 0.11 at subsequent inspections. I think this does not consider the possibility that (1) the crack doesn't leak enough to top of the head to give a visible indication; (2) it leaked initially, and formed some deposit that was missed in a early inspection before folks were sensitive to small amount of boric acid and doesn't leak anymore. In this case your probability of missing for subsequent inspections gets dramatically higher, like 1.

pg 29

The assumption is that the probability that they missed an leak is 0.06. That leak then instantly after the inspection initiates a crack of some length that then grows throughwall and then grows circumferentially to failure.

This assumes that there is no probability that a throughwall (or very deep) crack of some length already exists at the time of the inspection. This is essentially an inspection that is perfect in finding big cracks and only has a 0.06 chance of missing a small leak. But even they admit, that there is no way to tell from the deposits whether you are dealing with a small leak or a big OD crack.

Again it is impossible to know what CGR distribution they assumed in coming up with their times to failures, but the critical assumption is the perfect inspection.