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Mr. E. G. Igne, Staff Engineer
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
Mail Stop H-1016
Washington, D. C. 20555

Dear El:

BWR PRIMARY PIPING QUESTIONS

I have taken it upon myself to arbitrarily respond, in parallel with B. D. Liaw, with respect to P. Shewmon's questions pertaining to cracks in BWR primary piping. It is my understanding that these questions will be addressed at the meeting of the Metal Components Subcommittee on the 26th and 27th of May. I have a commitment in New York City at PVRC on the 26th, but do plan on making the meeting on the 27th assuming it will still be held.

The attached responses to the questions may put in perspective the direction in which the ASME XI Code is going with regard to austenitic piping. If you have questions concerning my response or if there are any changes in plans, I would appreciate being notified.

Very truly yours,

Spencer H. Bush
Senior Staff Consultant

SHB:dp

Attachment

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RESPONSE TO P. SHEWMON QUESTIONS

1. Recently ASME XI proposed and the Main Committee approved a new appendix analogous to Appendix A (LEFM) that uses a limit load approach to establish acceptable circumferential flaws in austenitic piping. The ASME XI Subgroup on Evaluation Standards (I chair) and the Working Group on Flaw Evaluation examined the elastic-plastic fracture mechanics (EPFM) and tearing modulus approaches in addition to limit load before settling on LL because of its simplicity. To my knowledge, this approach has been used in reports to the Regulatory Staff prior to ASME approval, and the Staff has accepted such analyses. Based on my personal contacts with the approach, I believe LL is an acceptable concept with adequate margins of safety. Incidentally, the analyses indicate that a 360° flaw more than 50% through-wall still has safety margins even under faulted loads. ASME XI is working on a similar approach for axial flaws in austenitic piping and both axial and circumferential flaws in ferritic piping.

2. I interpret this question as a subset of 1. If we can transform an indication into a flaw of known geometry and dimensions, we can analyze this "flaw" as to acceptability. An embedded flaw represents a relatively trivial condition. The rapidly growing IGSC crack is the significant case. The safe-end region is a specific case with bending, but poses no analytic problems.

3. This is a two-part question. The mechanical properties in terms of tensile and toughness aren't very different between sensitized and solution-treated material, provided there isn't very severe sensitization and coarse grains. Toughness as such shouldn't be an issue. The issue becomes one of how the crack grows through the wall. A worst case is one where the stress fields cause circumferential crack growth, followed by very uniform through-wall crack growth. Prior to the Duane Arnold incident, I considered such a crack growth pattern as a low probability. I still consider it as low probability, but higher than I prefer. Any bending movement (typical of nozzles) will bias the growth and leakage should occur as at Arnold. The problem becomes critical if uniform crack growth occurs more than 70% through-wall. Safety margins drop at ∿80% through-wall. With this caveat, I expect leak-before-break to be the high probability event.

4. Obviously, this must be answered by the Staff. The Code position would be to assume further crack growth, minimize credit for the remaining ligament, and put a "weld cap" over the crack which has the combined effect of thickening the wall so that a 100% 360° crack in the original pipe still has acceptable safety margins. A secondary benefit is that IGSCC will not propagate in the weld (it may grow by fatigue).

5. Not too good. Crack sizing in austenitics isn't easy, particularly with conventional equipment. I have seen major underestimates of crack size depending on the DAC level used. If one uses signal

above background, which isn't typical, a fairly accurate size is possible. With 50% DAC, sizing will be poor. Advanced techniques, if used, can do a pretty accurate job.

6. Again, the Staff must give a final answer. There are ASME XI repair weld procedures that can be and have been used. To my knowledge, the purpose usually is to buy time since it often requires several months to obtain replacement piping. The Code procedures have proceeded through the formal approval process including NRC member approval at Subgroup, Subcommittee and Main Committee levels.

   A weld cap makes continued examination using UT more difficult. I am personally aware that UT is done immediately after the weld to establish existence or absence of lack-of-bond. I believe that a meaningful NDE can be conducted if the weld cap is designed correctly. As cited previously, a correctly designed weld cap will accommodate a 100% 360° crack based on original pipe wall.

7. This is very sensitive to plant conditions. It may be very low in one plant and several man-rem per repair in another.

8. This is an NRC question. To my knowledge, there are no generic requirements other than the leak detection Regulatory Guide. It will be case-by-case.

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