BWR OWNERS' GROUP REGULATORY RESPONSE GROUP (RRG) T. J. Dente, Chairman

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June 8, 1984
RRG-8403

Mr. Harold R. Denton
Director of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

SUBJECT: Regulatory Response Group (RRG) Response to Inconel 182 Weld Butter Crack Indications

REFERENCE (1): RRG Meeting with NRC on Tuesday, June 5, 1984 to discuss indications identified at the Boston Edison Pilgrim Nuclear Power Station

In Reference (1), the RRG and the BWR Pipe Crack Owners Group met with you and your staff in order to provide the NRC with a reasoned response to the indications observed in the Inconel 182 weld butter in the RPV nozzle to safe end weld at the Pilgrim Nuclear Power Station. This letter serves to document the conclusions and reasoned response of that meeting and reiterates the basis for the continued safe operation of BWR Nuclear Units.

In early May 1984, during replacement of recirculation piping at Pilgrim, liquid penetrant indications were observed in Inconel 182 weld butter in the RPV nozzle to safe end weld. Based on recent laboratory tests, GE had concluded that Inconel 182 was susceptible to IGSCC and had recommended inspection of such welds during piping replacement programs. Inspections to date at Pilgrim have found indications in three out of ten recirculation inlet nozzle welds and one out of two recirculation outlet nozzle welds. The cracks were axially oriented and initiated in the Inconel 182 weld metal on the ID surface. Boat samples taken from the RPV recirculation outlet nozzle weld region confirmed intergranular (interdendritic) stress corrosion cracking.

The safety implication of the cracking in the Inconel 182 weld butter has been evaluated. The significant results from the evaluation are described here:

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- Cracking observed to date in the Inconel 182 weld butter has been predominantly axial with length approximately ½ inch. Such short axial cracks do not pose any safety concerns. The length of the axial cracks in the weld butter is inherently limited by the adjoining materials which are more resistant to IGSCC (Inconel 82 root pass and the unsensitized stainless steel safe end or low alloy steel nozzle). Even if the observed cracking were through-wall, the code intended safety margins are maintained. In fact, the critical crack size for a through-wall crack in the low alloy steel nozzle is in excess of 22 inches for the 12-inch diameter recirculation inlet nozzle and 27 inches for a 28-inch diameter outlet nozzle. The corresponding critical size for cracks in the stainless steel safe end is even larger. Clearly, the observed cracking is well below the critical size. Therefore, even if the crack propagates to be through-wall, leak-before-break will be maintained and the crack would be detected by the normal leak monitoring systems.

- IGSCC crack initiation time and crack growth rate in Inconel 182 are less severe than those in weld sensitized stainless steel. Therefore, the extent of cracking in the Inconel weld butter is expected to be similar to or less severe than that observed in 304 stainless steel piping welds. Thus there is time for orderly implementation of remedial measures. In any case, the observed cracking does not pose safety concerns.

- Inspection of Inconel 182 weld metal on RPV recirculation nozzle/safe end weld has been conducted at Duane Arnold as part of the safe end replacement program. No similar indications were found during this inspection. In addition, Type 308 stainless steel welds between the RPV nozzles and safe ends at Monticello showed no similar indications following inspection. The fabrication history of the Pilgrim RPV nozzle/safe end welds is currently being evaluated to determine whether the observed cracking could be due to metallurgical or residual stress factors unique to Pilgrim.

- Axial cracks in the Inconel weld metal which extend beyond the weld crown into the safe end or nozzle base material can readily be detected.

- While UT inspection of weld butter is more difficult, it can be done, especially with proper qualification on mockups with actual weldment geometry. Circumferential cracks which are of greater fracture concern can be detected with greater reliability.

- Leak-before-break margins remain valid and structural integrity is maintained.

Based on the above, it is believed that the observed cracking in the Inconel 182 weld butter does not pose any safety concerns, and is no worse than IGSCC previously discovered in BWR stainless steel piping and can be mitigated with an orderly remedial program.

During the course of discussions in Reference (1), an inquiry was made as to the interpretation of the I&E Bulletin 82-03 and I&E Bulletin 83-02 inspection scope. This inspection would, if performed on the safe end Heat Affected Zone (HAZ) in the safe end to nozzle weld in the recirculation system, provide added information regarding propagation of cracking into the safe end. The industry participant in Reference (1) representing the Hatch 2 Unit committed to an inspection of six (6) of the reactor recirculation system safe end-to-nozzle welds and will report the results to the NRC.

The BWR Pipe Crack Owners Group will be responding to the NRC further on this issue in approximately one month. During that period of time, both the Technical Advisory Committee and the Senior Representatives of the Owners Group will be meeting to define program and resource requirements for further investigating inspection, integrity and remedy application issues applicable to Inconel weld butter cracking.

Very truly yours,

Thomas J. Dente

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