June 22, 1984

POLICY ISSUE
(Information)

SECY-84-230A

For: The Commissioners

From: William J. Dircks
Executive Director for Operations

Subject: STRESS CORROSION CRACKING IN INCONEL WELD MATERIAL

Purpose: To update the Commissioners regarding the recirculation system pipe cracks found in Inconel weld material at Pilgrim Nuclear Power Station, and the status of NRC activities related to this issue.

Discussion: The staff issued an information paper (SECY-84-230) dated June 8, 1984 to inform the Commissioners of cracking found in the weld butters of the recirculation inlet and outlet nozzles and their respective safe ends at the Pilgrim Nuclear Station. The BWR Regulatory Response Group (RRG) provided a letter dated June 8, 1984 (Enclosure 1) outlining the RRG's basis for continued plant operation and containing a commitment to respond to the NRC with their plans addressing this issue with regard to inspections, piping integrity and remedial actions. The staff in a memorandum for H. Denton dated June 7, 1984 (Enclosure 2) provided its bases and recommendations that no immediate regulatory action is necessary.

The staff is continuing to review this matter. The staff has met with Boston Edison on June 16, 1984 to discuss their proposed repair methodology and will review the licensee's detailed submittal prior to plant start-up. Further, the staff will shortly convey its comments to RRG regarding items the staff believes should be included in the RRG program. The staff will keep the Commission informed and will provide its actions and/or recommendations following the review of the RRG program.

William J. Dircks
Executive Director for Operations

Enclosures:
As stated

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Enclosure 1

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

P.O. Box 270 • Hartford, Connecticut 06101 • (203) 666-6911 X 5489

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:

- 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

TJD/gap

Enclosure 2

JUN 7 1984

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Richard H. Vollmer, Director
Division of Engineering

SUBJECT: PILGRIM SAFE-END CRACKING GENERIC IMPLICATION - BASES FOR CONTINUED OPERATION

A meeting was held with representatives of the BWR Regulatory Response Group in Bethesda, Maryland, on June 5, 1984. The Group presented the inspection findings at Pilgrim including the extent and characterizations of cracks and other supporting laboratory data on the crack growth rate of Inconel-182 weld butter materials.

Based on an assessment of the information presented, the staff recommends that no immediate regulatory action be taken. The bases for this recommendation are summarized as follows:

- The cracks are short and in the axial direction, predominantly on the safe-end side, in the Inconel-182 weld metal. The maximum length and depth of the crack are about 0.75 and 0.7 inch, respectively. The width of the Inconel-182 weld butter is about 3/8 inch; i.e., the maximum extension of cracks into the 304 stainless steel safe-ends was about 3/8 inch. None of the cracks on the vessel nozzle side penetrated into the low alloy steel (508) nozzle.

- The Inconel-182 weld metal is a very tough material, similar to stainless steel. The laboratory crack growth rates for the Inconel-182 weld metal are in the same range as that of the 304 stainless steel. This indicates that the "leak-before-break" concept is valid.

- The critical crack length (beyond which the crack will tear in an unstable fashion) was calculated to be 22 inches or greater which indicates that there is a large margin when compared with the longest cracks found at Pilgrim. Further, the crack propagation would be expected in a manner that would penetrate the pipe wall and result in a high leakage rate well before reaching the critical length.

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- The staff believes these welds are within the scopes of inspections required by either IEB 82-03, 83-02 or Orders. Although different interpretations may be made by some utilities, any extensive cracking in the safe-ends should have been detected and reported. To date, no crack in these locations has been reported.

- The geometric constraint provided by the nozzle (thicker section) and the weld of the safe-end to the nozzle tends to create a residual stress pattern that, when coupled with pressure stresses, would cause cracks in the axial direction. Also, the cracks in the safe-ends should not extend too far toward the pipe side because the residual tensile stress near the inner surface tapers off away from the weld. Further, the low alloy carbon steel in the nozzle and the solution-annealed safe-end materials are highly resistant to stress corrosion cracking.

- Inspections by PT of the same surfaces were conducted at Monticello and Nine Mile Point Unit 1 when the safe-ends were removed for pipe replacement. No cracks were found. These PT examinations are required by the ASME Code Section XI. Specifically, the joint faces and adjoining areas are required to be liquid penetrant inspected prior to welding. It was this same inspection at Pilgrim that detected these cracks.

On the basis of the above discussion, the staff recommends that no immediate regulatory action be taken. However, the licensees should be required to develop on a priority basis reliable non-destructive inspection methods to minimize uncertainties regarding the extent of the cracking at these weld locations. In addition, the Owners Group should be requested to verify whether or not their scopes of inspection include these weld locations, and the industry plan to resolve this problem.

The staff will continue to monitor the field inspections and their results and obtain metallurgical samples for an independent assessment to confirm the cracking mechanism. As the assessment progresses, the staff will confer with the RRG and communicate any concerns identified during the week of June 11. By the end of June, the RRG should formally present the industry plan for resolving this potential generic issue.

/s/
Richard H. Vollmer, Director
Division of Engineering

cc: See Page 3

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