TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401
1630 Chestnut Street Tower II

May 31, 1985

BLRD-50-438/85-35
BLRD-50-439/85-32

U.S. Nuclear Regulatory Commission
Region II
Attn: Dr. J. Nelson Grace, Regional Administrator
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

Dear Dr. Grace:

BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2 - OPERATIONAL DEFECTS IN HIGH-PRESSURE INJECTION NOZZLES AND THERMAL SLEEVES - BLRD-50-438/85-35 AND BLRD-50-439/85-32 - FINAL REPORT

The subject deficiency was initially reported to NRC-OIE Inspector Don Quick on April 28, 1982 in accordance with 10 CFR 50.55(e) as NCR BLN NEB 8206. This was followed by our interim reports dated June 1 and July 28, 1982; March 1, April 11, and November 1, 1983; and May 16 and November 29, 1984. Enclosed is our final report. We consider 10 CFR Part 21 applicable to this deficiency.

If you have any questions, please get in touch with R. H. Shell at FTS 858-2688.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

J. A. Domer

for J. W. Hufham, Manager
Licensing and Regulations

Enclosure
cc (Enclosure):
Mr. James Taylor, Director
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Records Center (Enclosure)
Institute of Nuclear Power Operations
1100 Circle 75 Parkway, Suite 1500
Atlanta, Georgia 30339

Mr. H. B. Barklay
205 Plant Project Services
P.O. Box 10935
Lynchburg, Virginia 24506-0935

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ENCLOSURE
BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2
OPERATIONAL DEFECTS IN HIGH-PRESSURE INJECTION NOZZLES AND THERMAL SLEEVES
NCR BLN NEB 8206
BLRD-50-438/82-35, BLRD-50-439/82-32
10 CFR 50.55(e)

FINAL REPORT

Description of Deficiency

Recent inspections at several Babcock and Wilcox (B&W) operating 177FA plants revealed defects in the makeup/high-pressure injection (HPI) nozzle and their thermal sleeves in the makeup piping upstream of these nozzles. The nozzles are located on each reactor coolant cold leg between the reactor coolant pump and reactor vessel. The nozzles and sleeves are supplied by B&W under the nuclear steam supply system (NSSS) contract. The defects included:

- through-wall circumferential crack at the welded joint between the nozzle safe end and the first check valve upstream of the safe end,
- loose thermal sleeves,
- missing or worn thermal sleeve retaining buttons.

The thermal sleeve and retaining buttons were designed to avoid exposing the nozzle and pipe to a thermal shock condition be preventing sleeve movement in the upstream direction. These degraded mechanical restraints could allow unacceptable sleeve movement in the upstream direction and result in exposing the nozzle and pipe to a thermal shock condition.

Although the degraded components at the affected plants are the same, the resulting damage was not identical. Accordingly, B&W investigated this concern to determine its cause and to determine if it had generic implications for other B&W plants, including Bellefonte Nuclear Plant (BLN). The BLN nozzle configuration is similar to that at the affected plant except that it is a one-piece construction, while the nozzles for the affected plants have a welded safe end. There have been no similar deficiencies in the past for other BLN NSSS nozzles. There are no implications for other TVA plants.

This nonconformance can be attributed to a B&W design/manufacturing error in failing to assure tightness of the sleeves.

Safety Implications

The HPI system is intended to maintain emergency core cooling following a postulated reactor coolant system (RCS) rupture when RCS pressure is higher than core flood tank pressure. Failure of one or more HPI lines or nozzles would result in partial or total loss of HPI capability. If the thermal

sleeves become loose and move upstream, the makeup or HPI flow will no longer enter the flow of reactor coolant (RC) in midstream of the cold leg piping. Injection of cold makeup or HPI water close to the walls of the pipe/nozzle interface could result in a crack or break in the HPI nozzle or RCS piping resulting in a loss of coolant accident (LOCA).

Specifically, the concern is that should an HPI nozzle sustain a failure within the nozzle, particularly in the knuckle or bend radius region, the resultant LOCA may result in conditions that exceed the 10CFR50.46 acceptance criteria. Of concern is a nozzle failure that creates an opening larger than the inside cross sectional area of the attached HPI piping and smaller than the opening in the RC pipe cold leg that would be created by the complete severance of the nozzle at the nozzle to RC pipe weld. It should be noted that B&W has analyzed breaks at both the NPI nozzle to RC pipe weld and HPI piping and determined that no safety limits would be exceeded. Such an intermediate size break is not sufficiently larger to depressurize the RCS to the point that low-pressure injection would mitigate the event. It is, however,large enough to allow most of the HPI water to be lost out of the break to the reactor building. Operators may not have sufficient time to redirect HPI to the other HPI lines before the loss of reactor coolant out of the break result in fuel damage, and thereby, adversely affects the safety of operations of the paint.

Corrective Action

B&W has determined that there is no safety concern unless there is a cracked or loose thermal sleeve. With respect to nozzles that have not been degraded, failures are assumed only at the weld between the RC pipe and the nozzle forging and between the nozzle forging and the connecting HPI pipe. Emergency core cooling system analyses have shown that ruptures in these locations can be mitigated within the criteria of 10 CFR 50.46. Failures are not assumed within the nozzle forging itself because the forgings are heavily reinforced. Thus, failures within the forgings are considered to be of sufficiently low probability to not require evaluations.

This design basis (i.e., no failure within the forgings) assumes that the thermal sleeves within the nozzle remain in place as designed and that there is no loosening or cracking of the sleeve that would allow hot primary coolant or cool makeup or HPI fluid to flow between the thermal sleeve and the nozzle body. Thermal sleeve problems and subsequent nozzle failures will be prevented at BLN by assuring sleeve tightness.

In accordance with field change packages (FCPs) 211 and 212 for units 1 and 2, respectively, the Bellefonte HPI nozzle thermal sleeves were hard rolled into the 2 1/2" end of the nozzles and contact rolled at the 28" end. The contact roll was done such that the collar on the sleeve is in line contact with the nozzle inner wall. This second roll assures stability of the sleeve with respect to flow-induced vibration. Four small holes were drilled through the collar from the 28" pipe side to allow venting of fluids from between the rolled areas. Interim report No. 5 documented completion of the work required to implement FCPs 211 and 212.

B&W also submitted a stress report for the HPI nozzle thermal sleeve roll expansion to support TVA's review of the FCPs. However, the stress report did not document the adequacy of the fix for the life of the plant. Interim report Nos. 4 through 7 outlined TVA's concerns about the adequacy of the sleeve rerolling for the life of the plant and B&W's responses to those conc ns. TVA's remaining concern, as outlined in interim report No. 7, was as follows:

TVA requested B&W to provide a quantitative evaluation supporting maintenance of the rolled thermal sleeve/nozzle interface stress field for the design life thermal transients. In response, B&W said that the rolled interface design will be verified through periodic inspection of operating units prior to the time Bellefonte units go into service. TVA questioned how a near-term inspection program for the HPI nozzle thermal sleeves will verify the 40-year design life.

B&W provided the following response to this concern:

1. Use of Short-Term Inspection Results

   B&W previously stated that additional information from 177FA operating plant thermal sleeve inspections could be used to evaluate the necessity of performing further evaluations of the modified BLN configuration. By this, B&W does not mean that the short-term inspections themselves provide justification for the 40-year design life of the new design. Rather, B&W meant that if these inspections show any indications of problems with the sleeves, then additional testing and/or analyses could be performed to further justify the BLN design. If no problems are occurring, then additional justification is not warranted for BLN.

   Inspections performed over the past two years at B&W 177FA operating plants having both rerolled and original thermal sleeves show no indication of thermal sleeve degradation. Some of the 177FA operating plants which still have the original thermal sleeves have had no apparent sleeve degradation after more than ten years of service. This supports the conclusions that thermal sleeve integrity for the longer term is primarily a function of the rolled joint interface load.

   B&W's confidence in the modifications made at BLN was based on several considerations and not just on the recent favorable operating plant experience. B&W has also relied on the manufacturing history and inspection data for the timeframe from the early 1970s up to the time FCPs 211 and 212 were issued. To B&W's knowledge, there have been no occurrences of thermal sleeve degradation on 177FA operating plants since the FCPs were issued to TVA, and several inspections have been performed in this time period.

2. Interface Residual Stress Maintenance

   B&W has performed a qualitative analysis of the 177FA plant HPI nozzle/thermal sleeve configuration. The analysis indicates that

although an interface load loss occurs during the first couple of thermal cycles, no additional load loss was observed after the third cycle. B&W expects that similar results would be found for the BLN configuration if an analysis was performed.

Considering the difficulty and expense necessary to verify long-term maintenance of interface residual stresses, TVA concurs with B&W's judgment that additional engineering justification is not warranted at this time for the BLN design. It is probable that rolled interface thermal sleeve problems would be indicated at B&W 177FA plants prior to a similar occurrence at BLN because of the significantly greater accumulated service. Operating plant experience is reviewed through the Nuclear Experience Review Program as required by NUREG 0737, item I.C.5 and should determine if further inspection is worthwhile. If so, the preliminary plan is to perform radiographic inspections of the BLN units at the sleeve/nozzle outboard end interface area during the first refueling outage and at every fifth outage thereafter.

Because of the nature of this nonconformance, no action is required to prevent recurrence. BLN is the only TVA plant with a B&W-supplied nuclear steam supply system. The corrective action described above should prevent the sleeves from coming loose during plant operation.

NUC PR
5/31/85