CP&L

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OCT 23 1995

SERIAL: BSEP 95-0531

U. S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 1
DOCKET NO. 50-325/LICENSE NO. DPR-71
NUREG-0619 FEEDWATER NOZZLE AND SAFE END EXAMINATION RESULTS

Gentlemen:

Pursuant to Nuclear Regulatory Commission NUREG-0619, subsection 4.4.3.1(2), the Brunswick Steam Electric Plant (BSEP) hereby submits the enclosed information concerning the non-destructive examination of the feedwater nozzles and safe ends performed during Unit 1 Refueling Outage 9 (B110R1).

Please refer any questions regarding this submittal to Mr. George Honma at (910) 457-2741.

Sincerely,

G. D. Hicks
Manager — Regulatory Affairs
Brunswick Nuclear Plant

WRM/wrm

Enclosures
1. Discussion of Examination Results
2. Regulatory Commitments
3. Excerpts From ESR 95-00767

cc: Mr. S. D. Ebneter, Regional Administrator, Region II
Mr. D. C. Trimble, Jr., NRR Project Manager - Brunswick Units 1 and 2
Mr. C. A. Patterson, NRC Senior Resident Inspector - Brunswick Units 1 and 2
The Honorable H. Wells, Chairman - North Carolina Utilities Commission

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ENCLOSURE 1

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 1
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The following information is provided in accordance with Nuclear Regulatory Commission NUREG-0619, "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking," and pertains to the non-destructive examination (NDE) of feedwater sparger, nozzles, and safe ends performed at the Brunswick Steam Electric Plant, Unit 1 during Refueling Outage 9 (B110R1).

I. START-UP/SHUTDOWN CYCLES EXPERIENCED:

Brunswick Unit 1 has experienced 139 start-up/shutdown cycles since initial start-up. This quantity includes one (1) start-up/shutdown cycle since the previous inspection (B109R1).

II. NON-DESTRUCTIVE EXAMINATION RESULTS:

The attached portions of Engineering Evaluation (ESR) 95-00767 provide a summary of the examination results for the feedwater spargers conducted at the Brunswick Plant, Unit 1 during Refueling Outage 9 (B110R1). All four feedwater spargers were visually examined (VT-1 and VT-3) utilizing a remote underwater camera. Inspections included all flow holes and the eight (8) circumferential welds connecting the sparger arms to the tees .

The examination results for the circumferential welds indicate that there were no significant changes in length or orientation of previously documented heat-affected zone (HAZ) cracks and that no new cracks were apparent. There were no relevant indications reported on the tee-to-thermal sleeve welds. Also, no recordable indications or evidence of cracking were noted for the feedwater nozzles and safe ends.

The flow holes in all four feedwater spargers were visually examined (VT-1 and VT-3) utilizing a remote underwater camera. The inspection results were compared with the inspection results from the B108R1 and B109R1 refueling outages. This comparison showed no significant changes . The flow holes continued to show slight crack growth; however, no significant changes in length or pattern were noted. Additionally, no sparger segments had separated from around the flow holes. Therefore, as discussed in Enclosure 2, it is acceptable to operate for an additional cycle with the existing feedwater spargers.

III. NON-DESTRUCTIVE EXAMINATION METHODS:

By letter dated August 1, 1994 (Serial: BSEP 94-0299), CP&L submitted the results from the non-destructive examination of the Unit 1 feedwater spargers, performed during Refueling Outage 8 (B109R1), to the NRC for review. In a letter dated February 3, 1995 (Serial: BSEP 95-0014), CP&L requested NRC concurrence with plans to perform future examinations of the feedwater spargers utilizing a high resolution remote camera in lieu of liquid penetrant (LP) examinations. The NRC concurred with the use of the visual examination method by letter dated March 16, 1995.

All four (4) feedwater spargers were visually examined using a high resolution remote underwater camera. The spargers were examined for gross defects and missing fragments. All of the flow holes were inspected for cracking. The circumferential welds were inspected to the extent possible with the remote camera. The video tapes of the visual inspections from the current outage were compared with the inspection results of the previous outage with no significant changes identified.

Ultrasonic examinations were performed on the N4A, N4B, N4C, and N4D safe ends and inner blend radii in accordance with NUREG-0619. No reportable indications were recorded as a result of these examinations. These results are consistent with previous examinations.

IV. SYSTEM MODIFICATIONS AFFECTING FEEDWATER FLOW AND/OR TEMPERATURE:

During the B109R1 refueling outage, a digital feedwater control system was installed on Brunswick Unit 1. This system has provided improved stability in feedwater flow control, i.e., fewer flow fluctuations during low power operation. Additionally, the feedwater startup level control valve (SULCV) was replaced during the Unit 1 Reload 7 outage (B108R1).

V. ON-LINE LEAKAGE MONITORING:

No on-line leakage monitoring system for the detection of feedwater leakage past the feedwater thermal sleeves has been installed on the Brunswick Plant, Unit 1.

ENCLOSURE 2

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 1
NRC DOCKET NO. 50-325
OPERATING LICENSE NO. DPR-71
NUREG-0619 FEEDWATER NOZZLE AND SAFE END EXAMINATION RESULTS

EXCERPTS FROM ENGINEERING EVALUATION REPORT ESR 95-00767,
"UNIT 1 FEEDWATER SPARGER EVALUATION FOLLOWING
IVVI EXAMINATIONS"

PURPOSE

This ESR Evaluation is required as part of CP&L's commitment to inspect Feedwater spargers in accordance with NUREG-0619. As such, this evaluation accomplishes the following:

1) Documents the In-Vessel Visual Inspections (IVVI) performed on the Feedwater spargers during RFO B110R1.

2) Evaluates the current IVVI data relative to previous inspection results and analyses.

3) Provides justification to use the Feedwater spargers for another operating cycle in the as-found condition. (i.e. concludes that BNP-1 can safely operate in the present condition during the next fuel cycle (Cycle 10) without any operational changes or restrictions.)

CONCLUSIONS

The BNP-1 Feedwater spargers are "acceptable as is" for Operating Cycle 10. Crack growth experienced during Cycle 9 was minimal and, in most cases, unobservable. The postulated crack lengths at the end of Cycle 10 will not reduce the structural margins below allowable values. Furthermore, the probability and consequences of loose parts have not changed and have been fully considered by previous analyses. Therefore, the condition of the Feedwater spargers does not impose any restrictions to BNP-1 operation during the next cycle.

EVALUATION

1.0 DESIGN INPUTS

1.1 American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section XI, 1980 Edition through Winter 1981 Addenda

1.2 Technical Specifications for Brunswick Steam Electric Plant Unit 1

1.3 IVVI Inspection data from BNP-1 Refueling Outages 7, 8 and 9

2.0 EVALUATION

2.1 BACKGROUND

Feedwater sparger cracking is a BWR industry concern and has been observed at BNP-1 since 1979. Each of four feedwater spargers at BNP-1 has thirty-six (36) side drilled flow holes and three (3) circumferential butt welds. Each feedwater sparger tee has a horizontal welded seam which has four (4) flow holes located in it. Each sparger arm section is made from seamless bent pipe and contains sixteen (16) flow holes. Two sparger arms and a thermal sleeve are welded to each tee with circumferential butt welds.

The BNP-1 feedwater spargers have experienced two distinct types of cracking, as categorized below:

A. **Radial Flow Hole Cracks:** Radial cracks in random directions which appear as "sunburst" patterns centered around sparger flow holes.

B. **HAZ Cracks:** Cracks in the heat affected zone (HAZ) of the longitudinal welds in the sparger tee and in the HAZ of the circumferential welds attaching the sparger arms to the tee.

Radial Flow Hole Cracking

The root cause of the cracks around the flow holes is believed to be high-cycle thermal fatigue. Crack extension beyond approximately 0.5" is thought to be governed primarily by intergranular stress corrosion cracking (IGSCC) exacerbated by the creviced environment created by the crack surfaces.

Flow hole cracks were first observed in 1979 by visual inspection. Detailed mapping and measurements were accomplished by liquid penetrant (LP) examination of selected flow holes during Refueling Outage (RFO) No. 7 in 1990 to create a baseline for future reference. LP exams were performed again during RFO 8 in 1993 and indicated no significant changes.

HAZ Cracking

The root cause of the cracks in the weld HAZ regions is believed to be high cycle thermal fatigue, with crack extension beyond 0.5 inches primarily driven by IGSCC. HAZ cracks in the tee to sparger arm circumferential welds were first observed in 1990 by liquid penetrant (LP) examination during RFO 7. Detailed mapping and measurements were performed to create a baseline for future reference. LP exams were performed again during RFO 8, along with UT exams, and indicated no significant changes.

2.2 *INSPECTION PLAN*

Feedwater spargers are examined each refueling outage with a remote underwater camera in accordance with Periodic Test OPT-90.1 (Reference 3.6), which complies with NUREG-0619 (Reference 3.1). The inspections are recorded on video cassette for documentation and trending. The inspection frequency in OPT-90.1 is greater than required by NUREG-0619 (Reference 3.1), which requires inspection every second refuel outage.

2.3 *INSPECTION RESULTS*

RFO B109R1

Inspection Scope

All four feedwater spargers were visually examined for gross defects and missing fragments. LP examination was performed on fifty six (56) preselected flow holes and the twelve (12) circumferential welds. Welds with circumferentially oriented PT indications were also ultrasonically (UT) examined to size the length of the indications on the inside diameter (ID). Inspection results are summarized below and presented in more detail in Reference 3.4.

Circumferential Weld Inspection Results

Based on the LP examination results, six (6) of the sparger arm-to-tee welds showed OD cracking and were subsequently UT examined to determine crack lengths at the ID surface. The examination results are provided in Ref. 3.7 and are summarized in Table 1 below. All circumferential cracks were oriented towards the RPV centerline.

TABLE 1

Nozzle Azimuth	Tee-to-Arm Weld (Viewed from RPV centerline)	Length of LP Indication on O.D. (Inches)	Length of UT Indication on I.D. (Inches)
45°	Left	1.25	1.5
	Right	none found	not UT examined
135°	Left	2.25	2.5
	Right	2.0	2.3
225°	Left	1.8	2.1
	Right	2.0	2.25
315°	Left	2.1	2.25
	Right	none found	not UT examined

There were no relevant indications reported on the tee to thermal sleeve welds.

Flow Hole Inspection Results

A comparison of the LP examination results from RFO B109R1 with those of RFO B108R1 showed no significant changes. The flow holes continued to show slight crack growth, however no significant changes in length or pattern were noted. Additionally, no segments of the spargers had separated from around the flow holes.

RFO B110R1

Inspection Scope

All four feedwater spargers were visually examined (VT-1 and VT-3) with a remote underwater camera in accordance with BNP-1 Periodic Test 0PT-90.1 (Reference 3.6). Inspections included all flow holes and circumferential welds and were recorded on video cassette for documentation and trending (Reference 3.8).

Circumferential Weld Inspection Results

The examination results are provided in Reference 3.8 and indicate that there were no significant changes in length or orientation of previously documented HAZ cracks and that no new cracks were apparent. There were no relevant indications reported on the tee to thermal sleeve welds.

Flow Hole Inspection Results

A comparison of VT-1 exam results from RFO B110R1 with LP exam results of RFO B109R1 and RFO B108R1 showed no significant changes. The flow holes continued to show slight crack growth, however no significant

changes in length or pattern were noted. Additionally, no sparger segments had separated from around the flow holes.

2.4 *PREVIOUS ANALYSES*

Radial Flow Hole Cracks

Radial flow hole cracks were analyzed by General Electric (GE) in 1990 (Reference 3.2) for the issues summarized in Table 2.

TABLE 2

ISSUE	CONCLUSION
Enthalpy Balance	Analysis was performed based on postulated loss of pipe segments from the 45° sparger at five (5) different flow holes. Analysis results show that this condition would cause the enthalpy balance to redistribute slightly but still remain within specified design limits for both 100% and 105% rated flow conditions.
Lost Parts (loose pieces)	The consequences of postulated loose pieces from around flow holes were considered. Plausible transit paths and rest locations demonstrate that an unreviewed safety question as defined in 10CFR50.59 does not exist. Interference with control rod operation is not considered a credible event due to the tortuous transit path required.
Structural Integrity of Sparger Arms	The postulated loss of pieces from around flow holes was analyzed and determined not to adversely affect the structural integrity of sparger arms.

HAZ Cracks

HAZ circumferential cracks were analyzed by GE in 1991 (Reference 3.3) for the issues summarized in Table 3.

TABLE 3

ISSUE	CONCLUSION
Critical Flaw Size for Failure of Sparger	The results of the evaluations confirm that a through-wall crack of up to 244° around the sparger arm would not cause sparger failure. End of Cycle (EOC) crack lengths were estimated to be significantly less; therefore structural integrity of Feedwater spargers was concluded for all normal operating conditions during Cycle #9.
Circumferential Crack Growth	Maximum postulated crack growth in an eighteen month cycle, using IGSCC analysis, is 3.16 inches.
Lost Parts (loose pieces)	Complete severance and displacement of a sparger arm is not a credible scenario and therefore the consequences need not be considered. The consequences of a postulated loose piece from around flow holes has been considered by Reference 3.2 and does not pose a safety concern.
Feedwater Nozzle Cracking	The consequences of feedwater flowing out of an open crack and directly impinging on the blend radius of a FW nozzle was considered. Based on thermal cycling and system fatigue cracking, a crack no deeper than 0.9 inches could develop in one cycle. This is less than the flaw depth of 1.0 inch permitted in NUREG-0619. (Present crack orientation is towards the RPV centerline and thus precludes this scenario in the next cycle.)

2.4 DISCUSSION OF EXISTING CONDITION

Flow Hole Cracks

A comparison of VT-1 exam results from RFO B110R1 with LP exam results of RFO B109R1 and RFO B108R1 showed no significant changes. The flow holes continued to show slight crack growth, however no significant changes in length or pattern were noted. Additionally, no sparger segments had separated from around the flow holes.

Postulated crack growth through the end of Operating Cycle #10 is minimal based on recent slow growth and postulated growth mechanisms. End of Cycle (EOC) crack lengths are not predicted to exceed the cases analyzed and qualified in References 3.2 and 3.4. Therefore the previous analyses fully bound the postulated EOC condition and the conclusions reached by the analyses are considered applicable to the next operating cycle .

HAZ Cracks

Table 1 summarized the non-destructive examination results of the eight welds connecting the sparger arms to the tee during RFO B109R1. Review of the VT-1 data from RFO B110R1 indicates imperceptible growth in existing cracks and shows no new relevant indications. However, for the purposes of this evaluation, crack extension is conservatively estimated to be 0.2 inches. Therefore, the longest indication is considered to be 2.7" long on the left side of the 135° azimuth tee.

An analysis of the circumferential weld cracking (Reference 3.3) was previously prepared by GE and identified allowable conditions for continued operation for an additional eighteen month cycle. The analysis concluded that the maximum allowable length of a circumferentially oriented crack was

244° of the circumference, based on Net Section Collapse methodology. This equates to 14.1 inches at the OD surface and 12.9 inches at the ID surface. Since prior UT examinations indicate that crack lengths at the ID surface are slightly greater than at the OD surface, the ID limit is considered in this evaluation.

The crack growth rate predicted by GE in Reference 3.3 is 3.16 inches per operating cycle, based on conservative IGSCC growth rates from NUREG-0313, Revision 2 (Reference 3.5). A summary of existing conditions, limiting structural criteria, and postulated crack growth to the end of Operating Cycle 10 is presented in Table 4.

TABLE 4

ATTRIBUTE	CRACK DATA
Maximum Permitted Crack Length Based on Structural Analysis (Net Section Collapse Evaluation)	12.9" (244° of ID)
Maximum Crack Length Observed During RFO B110R1 Inspections	Approx 2.7"
Estimated Crack Growth Rate per Operating Cycle from Reference 3.3	≤ 3.16"
Postulated Maximum Crack Length at End of Operating Cycle #10	Approx 5.9"

Since the postulated maximum crack length at the end of Operating Cycle #10 is significantly less than the maximum length permitted by previous analysis (5.9" < 12.9"), it is therefore acceptable to operate for an additional cycle with the existing cracking in the feedwater spargers. The longest existing

crack is not predicted to reach critical flaw size during the next operating cycle.

Summary

In summary, the feedwater spargers are acceptable in the as-found condition for Operating Cycle #10 of Unit 1. There is no postulated scenario involving the spargers that will affect the safe operation of the plant and all design margins for the feedwater system will be maintained during the operating cycle. The predicted crack length at the end of this eighteen month cycle will not reduce the structural design margins for the spargers below the analyzed allowables. The condition of the feedwater spargers does not impose any restrictions to plant operation for the next operating cycle.

3.0 REFERENCES

3.1 NUREG-0619, "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking".

3.2 General Electric Company Evaluation No. RDE-46-1290, "BSEP Unit 1 Feedwater Sparger Crack Growth Assessment", December, 1990.

3.3 General Electric Company Report No. GE-NE-523-112-1191; DRF 137-0010, dated November, 1991, "Feedwater Sparger Circumferential Cracking Evaluation for Brunswick Units 1 and 2".

3.4 CP&L Engineering Evaluation EER 93-0462, Revision 0

3.5 NUREG-0313, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping", Revision 2

3.6 OPT-90.1, "In-Vessel, Core Spray, and Feedwater Visual Examination", Revision 14

3.7 General Electric Company Report No. BNP1-RFO-B109, IVV Inspection Report and Video Review

3.8 RFO B110R1 IVVI report, including OPT-90.1 data sheets and video cassettes.

DOCUMENT UPDATES

No document updates are required as a result of this ESR.

ESR ACTION ITEMS

No ESR action items are required as a result of this ESR. Future inspections and reportings are governed by OPT-90.1 (Reference 3.6), which assures that the USNRC NUREG-0619 (Reference 3.1) requirements are met.

ENCLOSURE 3

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NO. 1
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LIST OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Carolina Power & Light Company in this document. Any other actions discussed in the submittal represent intended or planned actions by Carolina Power & Light Company. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify the Manager-Regulatory Affairs at the Brunswick Nuclear Plant of any questions regarding this document or any associated regulatory commitments.

Commitment	Committed Date or Outage
1. Submit results of Unit 1 feedwater sparger and safe end examination results obtain in accordance with NUREG-0619, "BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking."	B111R1 + 6 months