December 13, 1983

Docket No. 50-324

Mr. E. E. Utley
Executive Vice President
Carolina Power & Light Company
Post Office Box 1551
Raleigh, North Carolina 27602

Dear Mr. Utley:

SUBJECT: ORDER CONFIRMING CP&L COMMITMENT RE IGSCC INSPECTION

Re: Brunswick Steam Electric Plant, Unit 2

The Commission has issued the enclosed subject Order related to intergranular stress corrosion cracking (IGSCC) inspection for the Brunswick Steam Electric Plant, Unit 2.

A copy of this Order is being filed with the Office of the Federal Register for publication. Also enclosed is a copy of the Commission's Safety Evaluation.

Sincerely,

Original signed by/

Domenic B. Vassallo, Chief
Operating Reactors Branch #2
Division of Licensing

Enclosures:
1. Confirmatory Order
2. Safety Evaluation

cc w/enclosures:
See next page

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DL:AD-SA	DE:DIR
FMiraglia*	RVollmer*
12/06/83	12/07/83

*Mr. Miraglia and Mr. Vollmer - concurrence on Restart letter concurrence.

Mr. E. E. Utley
Carolina Power & Light Company
Brunswick Steam Electric Plant, Units 1 and 2

cc:

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of CAROLINA POWER & LIGHT COMPANY (Brunswick Steam Electric Plant, Unit 2)	)	Docket No. 50-324

ORDER CONFIRMING CAROLINA POWER & LIGHT COMPANY
COMMITMENT RE IGSCC INSPECTION

I.

The Carolina Power & Light Company, (the licensee, CP&L) is the holder of Facility Operating License No. DPR-62, which authorizes the licensee to operate the Brunswick Steam Electric Plant, Unit 2 (the facility), at power levels not in excess of 2436 megawatts thermal. The facility is a boiling water reactor located at the licensee's site in Brunswick County, North Carolina.

II.

As a result of inspections conducted at 18 operating boiling water reactors (BWRs) in conformance with recent IE Bulletins (IE Bulletin No. 82-03, Revision 1, "Stress Corrosion Cracking in Thick-Wall, Large-Diameter, Stainless Steel, Recirculation System Piping at BWR Plants," and IE Bulletin No. 83-02, "Stress Corrosion Cracking in Large-Diameter Stainless Steel Recirculation System Piping at BWR Plants"), a potential safety concern regarding intergranular stress corrosion cracking (IGSCC) in primary system piping was identified. These bulletins requested selected licensees to perform a number of actions regarding inspection and testing of pipe welds.

Results of these and other inspections pursuant to IE Bulletins 82-03 and 83-02 have revealed extensive cracking in large-diameter recirculation and residual heat removal system piping. In almost every case, where inspections were performed, IGSCC was discovered and, in many cases, repairs, analysis, and additional surveillance conditions were required. In view of the foregoing and the fact that the facility is similar in design to plants where IGSCC has occurred, there was a significant potential for IGSCC to exist in this facility. Therefore inspection was required to determine the extent of IGSCC and to ascertain, if necessary, the degree of remedial action.

On August 26, 1983 an Order was issued to the licensee which required that the facility be shutdown by November 1, 1983 and an IGSCC inspection be performed (this Order was modified on October 28, 1983 to allow the shutdown to be as late as November 9, 1983). On November 2, 1983 the facility was shutdown pursuant to Section III.B of the Order and an IGSCC inspection was performed pursuant to Section III.C of the August 26, 1983 Order.

In a November 28, 1983 report, as supplemented by two letters each dated November 30, 1983, the licensee discussed its IGSCC inspection pursuant to Section III.C.5 of the Order. This report concluded, based on certain compensatory action and the inspection results, that operation of the facility was justified through April 30, 1983.

The staff review of the licensee's report dated November 28, 1983 as supplemented by two letters dated November 30, 1983, has been completed and is documented in the Safety Evaluation dated December 13, 1983. The NRC letter dated December 13, 1983 notified the licensee that the facility could be returned to power. Although the calculations discussed in the above report indicate that the cracks in the 8 overlay repaired welds or the 11 unrepaired welds will not progress to the point of leakage during the remainder of this fuel cycle, and margins are expected to be maintained over crack growth which could compromise safety, uncertainties in crack sizing and growth rate still remain.

Because of these uncertainties, we have determined that improvements in the monitoring in the containment for unidentified leakage are required; therefore, the changes to the limiting conditions for operation and surveillance requirements imposed by the August 26, 1983 Order should be continued. These enhanced surveillance measures will provide adequate assurance that possible cracks in pipes will be detected before growing to a size that will compromise the safety of the plant.

The staff also has some concern regarding the long-term growth of IGSCC cracks and its effect on the long-term operation of the plant. Therefore, we have determined that plans for inspections, corrective action and/or modification including replacement of the recirculation and other reactor coolant pressure boundary piping systems during the next refueling outage must be submitted at least 30 days before the start of the next refueling outage. In addition, the staff has determined that a justification for continued operation must be submitted to NRC for review and approval prior to startup after the next refueling outage.

By letter dated November 28, 1983, as supplemented by two letters each dated November 30, 1983, the licensee committed to the above described conditions on leakage monitoring and early submittal of inspection and/or modification plans. I have determined that the public health and safety requires that these commitments should be confirmed by an immediately effective Order.

III.

Accordingly, pursuant to sections 103, 161i, 161o, 182 and 186 of the Atomic Energy Act of 1954, as amended, and the Commission's regulations in 10 CFR Parts 2 and 50, IT IS HEREBY ORDERED EFFECTIVE IMMEDIATELY THAT:

A. Notwithstanding the current Technical Specifications for the facility the following compensatory measures shall be implemented:

1. The reactor coolant system leakage shall be limited to a 2 gpm increase in unidentified leakage within any 24 hour period (leakage shall be monitored and recorded once every 4 hours). Should this leakage limit be exceeded, the unit shall immediately start an orderly shutdown. The unit shall be placed in at least hot shutdown within the next 12 hours and in cold shutdown within the following 24 hours.

2. At least one primary containment sump collection and flow monitoring system shall be operable. With the primary containment sump collection and flow monitoring system inoperable, restore the inoperable system to operable status within 24 hours or immediately initiate an orderly shutdown and be in at least hot shutdown within the next 12 hours and in cold shutdown within the following 24 hours.

B. The licensee shall place the facility in cold shutdown by April 30, 1984.

C. Plans for inspections, corrective actions, and/or modification, including replacement of the recirculation and/or coolant pressure boundary piping systems, during the next outage which is scheduled to begin in March 1984 but which may begin as late as April 30, 1984 shall be submitted at least 30 days before the start of that outage.

D. At least one month prior to startup of the facility after its next refueling outage, a justification for continued operation shall be submitted for NRC review and approval.

E. The Director, Division of Licensing, may, in writing, relax or terminate any of the above provisions upon written request from the licensee, if the request is timely and provides good cause for the requested action.

IV.

The licensee may request a hearing on this Order within 20 days of the date of publication of this Order in the Federal Register. Any request for a hearing shall be addressed to the Director, Office of Nuclear Reactor Regulation, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555. A copy shall also be sent to the Executive Legal Director at the same address. A REQUEST FOR HEARING SHALL NOT STAY THE IMMEDIATE EFFECTIVENESS OF THIS ORDER.

If a hearing is to be held, the Commission will issue an Order designating the time and place of any such hearing.

If a hearing is held concerning this Order, the issue to be considered at the hearing shall be whether, on the basis of the matters set forth in Section II of the Order, the licensee should comply with the requirements set forth in Section III of this Order. This Order is effective upon issuance.

FOR THE NUCLEAR REGULATORY COMMISSION

Darrell G. Eisenhut, Director
Division of Licensing

Dated at Bethesda, Maryland
this 13 day of December, 1983.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO INTERGRANULAR STRESS CORROSION CRACKING

CAROLINA POWER & LIGHT COMPANY

BRUNSWICK STEAM ELECTRIC PLANT, UNIT 2

DOCKET NO. 50-324

1.0 Introduction

Brunswick Unit 2 was shut down on November 2, 1983 in accordance with the order issued on August 26, 1983 to inspect all ASME Class 1 austenitic stainless steel piping that are susceptible to intergranular stress corrosion cracking (IGSCC) in the Recirculation, Residual Heat Removal (RHR), Core Spray and Reactor Water Clean-up (RWCU) piping systems. Carolina Power & Light Company (the licensee) reported the results of the inspection in a meeting with the NRC staff on November 23, 1983 (see meeting summary dated November 25, 1983 - reference 1) and in a subsequent letter dated November 28, 1983 (reference 2). In addition, two letters dated November 30, 1983 (Serial number: LAP-83-549, reference 3, and serial number: LAP-83-554, reference 4) included information regarding weld defects and residual stresses, respectively.

During this shutdown period, ultrasonic examinations were performed on 131 nonconforming welds. Of these, 102 welds were in the Recirculation system, 5 welds were in the RHR system and 24 welds were in the RWCU system. The Core Spray system piping is made of carbon steel which is resistent to IGSCC. The licensee indicated that all Class 1 welds susceptible to IGSCC in the above mentioned piping systems were ultrasonically examined.

Background

Personnel from General Electric (Atlanta) and Lambert, McGill, and Thomas (LMT) performed the ultrasonic testing (UT) for the licensee. Region II of NRC has determined that their UT procedures, calibration standards, equipment and

IGSCC detection capabilities were satisfactorily demonstrated in accordance with I&E Bulletin 83-02, and the same procedures and techniques were used in the UT examination. Region II also indicated that all their UT personnel conducting these inspections have received appropriate training in IGSCC inspection using cracked thick-wall pipe specimens. The "amplitude-drop" method was used for crack depth measurements, but additional crack depth measurements using crack tip diffraction was performed on all defective welds that were not repaired. The worst of the two crack depth measurements was used in the flaw evaluation of the unrepaired welds. The results of the UT examinations indicated that a total of 19 welds showed reportable linear indications, of which eight are 28" Recirculation welds, two are 22" Recirculation Manifold welds, five are 12" Recirculation Riser welds, one is 20" RHR weld and three are 6" RWCU welds.

All reported UT indications were short and shallow, and were in the weld heat-affect-zone (HAZ). Short axial cracks with depths not over 20% of the wall thickness were reported in two 28" Recirculatin welds and one 20" RHR weld. The deepest circumferential crack, which had a depth of 22% of the wall thickness, was reported in a 28" Recirculation weld (2-B32-28"-B5). Except for weld 2-B32-22"-AM), the reported crack lengths in all defective welds did not exceed 2.375". Weld 2-B32-22-AM-5 was reported to have a total crack length of 11.5" (about 17% of the circumference) and a maximum crack depth of 20% of the wall thickness.

NUTECH performed flaw evaluations on all defective welds for the licensee. The evaluations were based on the methodology provided in the new ASME Code Section XI IWB-3600. The new Code IWB-3600 provides flaw acceptance criteria for the austenitic stainless steel piping based on a limit load approach which was approved by the ASME Main Committee in May 1983 and is expected to be published later this year. The results of NUTECH's flaw evaluations (Reference 1), including crack growth calculations, indicated that 11 (eight 28" Recirculation welds, two 22" Recirculation Manifold welds, one 20" RHR weld) of the 19 defective welds did not require weld overlay repair because the calculated flaw sizes of those 11 welds at the end of a 6-month period did not even exceed two-thirds of the new Code allowable limit.

NUTECH also performed weld overlay design and repairs for the licensee. Eight of the 19 defective welds were weld overlay repaired. The overlay thickness was designed to meet the new IWB-3600 limits. The overlay applied to the eight defective welds has a minimum thickness of 0.2 inch. The minimum lenghs of the overlay varied from 3.8 inches to 5 inches, and were selected to reinforce the weld structure and minimize the end effects. Region II of NRC Has confirmed that the weld overlay repairs were performed in accordance with qualified and approved procedures consistent with ASME Code requirements.

The licensee reported that the as-measured axial shrinkages from the eight overlay repair welds were in the range of 0.22 inch to 0.37 inch. The stresses caused by this shrinkage on the 11 unrepaired defective welds were calculated to be very small. The largest value was reported to be 664 psi. In the crack growth calculation, the small shrinkage stresses due to weld overlay were not considered.

During the repair process there were three defects noted (see reference 3). One of the defects was a "blowout", with an underlying pinhole, one was a pinhole and one was a quarter-inch long axial crack indication. These weld defects were adequately repaired.

Evaluation

We reviewed the licensee's submittals, including the analysis of the weld overlay designs, and the calculation of IGSCC crack growth to support the continuing service for a 5-month period (approximately 3600 hours). Our review included the nine overlay repaired welds and the 11 unrepaired defective welds (eight 28" Recirculation welds, two Recirculation manifold welds and one 20" RHR weld). The licensee indicated that Brunswick Unit 2 will enter the refueling operational condition approximately March 15, 1983, but no later than April 30, 1984.

In the IGSCC crack growth calculations, which bounded the crack growth in all the unrepaired defective welds, the stress intensity factor was calculated by conservatively assuming the crack at the reported crack depth (22% of the wall thickness) to be 360° in circumference. The highest sustained stress calculated for any weld was 9680 psi. This bounding value was used for all the crack growth calculations. The results of the calculations indicated that the worst calculated flaw size at the end of a five month period did not exceed 30% of the wall thickness. This is well within the staff's criterion of two-thirds of the new Code allowable limits.

We have reviewed the IGSCC crack growth calculations and agree with their conclusion that the continued operation for a period of five months with the 11 defective welds in as-is condition is acceptable. Our conclusion is based on the following considerations:

(1) Code design safety margin

We performed an independent crack growth calculation to ensure that the Code design safety margin in the 11 unrepaired defective welds in maintained. The crack growth in the 11 unrepaired defective welds was bounded by this calculation. A sustained stress of 10 Ksi, including the largest shrinkage stress of 664 psi, was used in this calculation. The stress intensity factor (K_I) was calculated based on a cylindrical model of 28 inches diameter pipe assuming a complete 360° circumferential crack at a depth of 22% throughwall. The crack growth rate curve used in our calculation is more conservative than that used by NUTECH, and is an upper bound of GE and EPRI's crack growth data in furnace sensitized material and tested in 0.2 ppm O_2 water. Our calculations showed that the initial crack depth of 22% would grow to a depth of about 33% at the end of a 5 month period as the crack is relatively short (17% of the circumference). Even if the reported initial crack depth is doubled to 44% of wall thickness, the final crack size at the end of a 5 month period is calculated to be only about 52% of the wall thickness which is still well within the new Code allowable limit (75% of wall thickness). Therefore, we conclude the Code design safety margin will be maintained in the 11 defective unrepaired welds during the continued operation for a period of 5 months.

NUTECH's overlay design for the eight defective welds (five 12" riser welds and three 6" RWCU welds) was based on the conservative assumption that all cracks were throughwall cracks. This assumption eliminates the concern regarding the uncertainties in the UT sizing of crack depth because crack depth need not be considered in the overlay design. The length of the reported cracks in the eight repaired welds were all very short which varied from 0.75 to 3.25 inches (about 4% to 9% in circumference). Because of the compressive residual stresses formed at the inner surface and extending approximately half-way through the wall after weld overlay, crack growth in the circumferential direction is expected to be very limited. Based on the limit load analysis, the assumed short throughwall cracks would not have significant impact on the Code design safety margin in the eight overlayed welds. Therefore, we conclude that NURECH's overlay repairs will provide added assurance of safe operation during the next 5 month period.

(2) Short cracks

All 11 unrepaired defective welds have relatively short cracks. Except for one unrepaired weld which has a total crack length of 17% of the circumference, the crack length in the other 10 unrepaired welds is less than 10% of the circumference. Based on limit load analysis, such short length flaws, even assumed throughwall, will not have a significant effect on the structural integrity of the weld

(3) Leak Testing

A hydrostatic test in accordance with ASME Section XI will be performed on joint 2-G31-6"-15 prior to start-up. The other joints cannot be isolated from the reactor; therefore, an in-service leak test will be performed at normal operating pressure and temperature during start-up. These tests will give adequate assurance of the integrity of the overlays.

(4) Short operating period

The licensee indicated that Brunswick Unit 2 will be in refuel mode no later than April 30, 1984, therefore, the operating period prior to the next refuel outage would not be more than 5 months. Based on our recent experience with BWRs operating with confirmed IGSCC cracked piping welds, we do not expect that the reported short cracks in the 11 unrepaired welds would grow to the extent of compromising the safety of the plant during the continued operation of the plant for a period of 5 months.

(5) Augmented Leak Detection

Although the conservative calculations discussed above indicate that the cracks in the unreinforced welds will not progress to the point of leakage during the next 5 month period, and very wide margins are expected to be maintained over crack growth to the extent of compromising safety, uncertainties in crack sizing and growth rate still remain. Because of these uncertainties, it is prudent to tighten the requirements for the monitoring of unidentified leakage.

The licensee has agreed to additional monitoring and tighter limits on unidentified leakage, which are summarized below:

1. The reactor coolant system leakage will be limited to a 2 gpm increase in unidentified leakage within any 24 hour period (leakage shall be monitored and recorded once every 4 hours). Should this leakage limit be exceeded, the unit will immediately start an orderly shutdown. The unit will be placed in at least hot shutdown within the next 12 hours and in cold shutdown within the following 24 hours.

2. At least one primary containment sump collection and flow monitoring system will be operable. With the primary containment sump collection and flow monitoring system inoperable, restore the inoperable system to operable status within 24 hours or immediately initiate an orderly shutdown and be in at least hot shutdown within the next 12 hours and in cold shutdown within the following 24 hours.

We concluded that implementation of the above measures will provide adequate assurance that possible cracks in pipes will be detected before growing to a size that could compromise the safety of the plant.

Summary and Conclusions

We have reviewed the licensee's submittals regarding the actions taken or to be taken during this confirming order outage on the inspection, analyses and repairs of Recirculation, RHR and RWCU piping systems in the Brunswick Unit 2 plant. This includes a description of the defects found, description of repairs, stress and fracture mechanics analysis.

We conclude that the Brunswick Unit 2 plant can be safely returned to power and operated in its present configuration at least for one 5-month period.

Nevertheless, we still have concern regarding the long term growth of small IGSCC cracks that may be present but not detected during this inspection. Therefore, we require that plans for inspection and/or modification of the recirculation and other RCPB piping systems during the next refueling outage be submitted for our review at least one month before the start of the next refueling outage.

Principal Contributors: W. Koo
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Date: December 13, 1983