CP&L

Carolina Power & Light Company

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AUG 05 1988

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Senior Vice President
Operations Support

SERIAL: NLS-88-182

United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 & 50-324/LICENSE NOS. DPR-71 & DPR-62
RESPONSE TO NRC BULLETIN 88-04, "POTENTIAL SAFETY-RELATED PUMP LOSS"

Gentlemen:

The NRC issued NRC Bulletin 88-04, "Potential Safety Related Pump Loss," on May 5, 1988. The purpose of the bulletin is to request all licensees to investigate potential design concerns involving safety-related pumps. The NRC concerns involve the potential for a pump to dead-head when it is operating in the minimum flow mode in parallel with another pump, and the adequacy of the minimum flow capacity.

The NRC requested that within 60 days of receipt of the bulletin, licensees provide a written response that (a) summarizes the problems and the systems affected, (b) identifies the short-term and long-term modifications to plant operating procedures or hardware that have been or are being implemented to ensure safe plant operations, (c) identifies an appropriate schedule for long-term resolution of this and/or other significant problems that are identified as a result of this bulletin, and (d) provides justification for continued operation particularly with regard to General Design Criterion 35 of Appendix A to 10CFR50, "Emergency Core Cooling" and 10CFR50.46, "Acceptance Criteria for Emergency Core Cooling System for Light Water Nuclear Power Reactors."

On July 5, 1988, Carolina Power & Light Company (CP&L) submitted a letter stating that the Company is participating in a BWR Owners' Group program to respond to NRC Bulletin 88-04, and that within 30 days of receipt of the Owners' Group evaluation, CP&L would submit a plant specific response based on the Owners' Group evaluation.

Carolina Power & Light Company received the Owners' Group evaluation on July 6, 1988. Attached is the Company's response to NRC Bulletin 88-04.

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Please refer any questions regarding this submittal to Mr. Stephen D. Floyd at (919) 836-6901.

Yours very truly,

L. W. Eury

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Enclosure

L. W. Eury, having been first duly sworn, did depose and say that the information contained herein is true and correct to the best of his information, knowledge and belief; and the sources of his information are officers, employees, contractors, and agents of Carolina Power & Light Company.

Ruby R. Morgan
Notary (Seal)

RUBY R. MORGAN NOTARY PUBLIC WAKE COUNTY, N.C.

My commission expires: 11/27/89

cc: Dr. J. Nelson Grace
Mr. W. H. Ruland
Mr. B. C. Buckley

ENCLOSURE 1

BRUNSWICK STEAM ELECTRIC PLANT, UNITS 1 AND 2
NRC DOCKETS 50-325 AND 50-324
OPERATING LICENSES DPR-71 AND DPR-62

I. SUMMARY OF PROBLEM AND AFFECTED SYSTEMS

A. Summary of Problem

The original design basis for sizing the minimum flow lines for safety-related boiling water reactor (BWR) systems is to provide sufficient flow to avoid overheating the pumps due to low flow. However, current pump vendor guidelines for minimum flow are based on avoiding hydraulic instability in addition to avoiding pump overheating, leading to higher suggested minimum flow values than those used in BWR design. Hydraulic instabilities can occur at low flow rates due to flow separation across the impeller vane, which can lead to asymmetrical shaft and bearing loads in addition to pump and piping vibration. Since the pump vendor guidelines are only applicable for continuous[1] or intermittent[2] low flow operation, there are no guidelines for low flow limits for infrequent operation such as that experienced for only a limited postulated range of BWR loss-of-coolant accident (LOCA) events.

In addition, the pump minimum flow rate can be reduced (possibly leading to a condition where the pump is being run dead-headed) if there is a single minimum flow line for a pair of pumps operating in parallel. If the pumps have different pump shutoff heads, the pump with the higher shutoff head will deliver a greater flow rate; if there is a significant difference between the shutoff heads, the pump with the lower shutoff head may become dead-headed.

When the minimum flow discharge lines from two or more pumps join at some point to form a common line, there is a potential for interaction between the pumps. If the piping configuration is not controlled, the pump with the higher discharge pressure could reduce the flow through the pump with lesser discharge pressure to the point where it is inadequate for long-term integrity.

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[1] Continuous operation is considered as more than two cumulative hours at minimum flow in any 24-hour period.

[2] Intermittent operation is less than two cumulative hours of minimum flow operation in any 24-hour period.

If the pumps' minimum flow discharge lines are orificed (backloaded) in the individual pump discharge lines prior to the junction between the two pipes, and if the common line is large enough in flow area such that its resistance is a relatively small part of the overall hydraulic resistance, there should be little adverse pump-to-pump interaction. They can be expected to operate individually or in unison with no problems.

However, if the minimum flow discharge lines are not individually orificed, but the common line is orificed or provides greater flow resistance than the individual lines, interaction between the two pumps may occur. The severity of the attenuation of minimum flow through any pump depends on the shape of the head-flow curves of the pumps, and the magnitude of the mismatch between the pumps.

If the characteristic curve is such that a small change in flow results in a relatively large change in developed head, it is probable that little operational difficulty would result from an undesirable piping configuration. However, if a relatively large change in flow resulted in only a small change in developed head, some problems could occur. Further, the rate of attenuation of minimum flow through the lesser pump would be expected to accelerate with time.

B. <u>Affected Systems</u>

The BWR Owners' Group submittal identified several systems that may be affected by this problem, including the residual hear removal (RHR), core spray (CS), high pressure coolant injection (HPCI), reactor core isolation cooling (RCIC) and the feedwater coolant injection (FWCI) system. Each system has been reviewed by Carolina Power & Light Company, and it has been determined that the RHR, CS, and HPCI pumps fall within the scope of this bulletin for the Brunswick Steam Electric Plant, Units 1 and 2.

C. <u>Potential for Dead-Heading</u>

The RHR pumps' minimum flow bypass piping is the only design that utilizes common discharge piping.

The BSEP RHR system consists of two loops of RHR with each loop containing two RHR pumps. The two pumps in each loop have separate three-inch minimum flow lines which tie into a common four-inch discharge line which ties into a sixteen-inch discharge to the suppression pool.

The three-inch minimum flow lines for the RHR pumps contain restricting orifices prior to connecting to the common four-inch discharge line. A piping resistance calculation was performed to show that the line losses in the common four-inch discharge piping are a small part of the overall resistance, and therefore dual pump operation should not present adverse pump-to-pump interaction. In addition, this calculation also shows that if one of the RHR pumps is assumed to be "strong" based on the developed head, dual pump operation still should not present adverse pump-to-pump operation.

D. Adequacy of Pump Minimum Flow

BWR operating experience does not indicate any excessive wear to pumps when operating under the currently specified minimum flow conditions. That is, no such reported wear has resulted in indicated degradation in pump performance.

System operation in the minimum flow mode is limited to pump startup during surveillance testing, pump start for suppression pool cooling and during system start on a LOCA signal. The total expected time in the minimum flow mode over the plant life is at most one percent of the guideline recommended by the pump vendors for intermittent operation.[3] Therefore, the potential for excessive wear attributable to minimum flow operation is negligible.

Recent inspection of some BWR RHR pumps has indicated no pump impeller damage due to minimum flow that could potentially degrade pump performance over the inspection period. It is estimated by GE that the pumps had been intermittently operated in the minimum flow mode for up to 30 hours during this period. This further substantiates that short-term operation in the minimum flow mode has little or no impact on pump life.

Pump wear attributable to minimum flow operation is not a significant contributor to total system unavailability compared to other contributors, such as loss of emergency power, loss of cooling, etc. This is based on BWR operating history, which indicates no occurrences of system unavailability upon demand due to pump wear incurred in minimum flow operation.

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[3] Some pump vendors recommend minimum flow guidelines for intermittent operation, where intermittent operation is defined as less than two cumulative hours of minimum flow in any 24-hour period. For a plant design life of 40 years, this is equivalent to approximately 30,000 hours. Similar minimum flow limits have been suggested by other pump vendors.

During the shutdown cooling mode of RHR operation, the minimum flow bypass line is isolated prior to RHR pump start to prevent undesirable changes in the reactor vessel and suppression pool levels. Administrative controls in the operating procedures ensure that during this mode of operation, the pump start and the establishment of the main flow path are done essentially simultaneously. Therefore, "...damage resulting from operation and testing in the minimum flow mode..." is not considered applicable during shutdown cooling.

Brunswick Plant Specific Information

RHR Pumps: The BSEP RHR pump in-service testing, along with scheduled surveillance testing, has not revealed any signs of pump degradation that can be attributed to inadequate pump minimum flow.

It is estimated that the RHR pumps have operated in the minimum flow mode for less than ten hours total.

Core Spray Pumps: The BSEP core spray pump inservice testing, along with scheduled surveillance testing, has not revealed any signs of pump degradation that can be attributed to inadequate pump minimum flow.

It is estimated that the core spray pumps have operated in the minimum flow mode for less than five hours total.

High Pressure Coolant Injection (HPCI) Pump: The BSEP HPCI pump inservice testing, along with scheduled surveillance testing, has not revealed any signs of pump degradation that can be attributed to inadequate pump minimum flow.

It is estimated that the HPCI pump has operated in the minimum flow mode for less than two hours.

II. Short-Term and Long-Term Modifications

Operation in the minimum flow mode, which includes the potential for dead-head operation, is already minimized to the short periods of pump startup during routine testing and to system startup upon a LOCA signal. Based on pump vendor guidelines and operating experience, operation in the minimum flow mode, including dead-heading, is not expected to adversely affect pump operation. In addition, pumps within the industry have been inadvertently operated in the minimum flow and dead headed conditions for significant periods of time. These pumps continue to operate satisfactorily with no indications of adverse consequences. Inspections of pumps that have been normally operated, including testing, indicate no significant wear from operating at the low flow rates.

In order to best ensure that the applicable safety-related pumps are operated in the minimum flow mode for the least possible duration, applicable operating and test procedures will be revised incorporating precautionary statements to limit minimum flow operation to the least possible duration.

III. Schedule

The revisions described in Item II, above, will be completed by February 1, 1989.

IV. Justification for Continued Operation

The concerns stated in NRC Bulletin 88-04 are summarized as follows:

1. With two pumps operating in parallel in the minimum flow mode, one of the pumps may be dead-headed resulting in pump damage or failure.

2. Installed minimum pump flows may not be adequate to preclude pump damage or failures.

These concerns are addressed by the responses below which provide the basis for concluding that continued operation of BSEP is justified.

A. All Class 1, 2, and 3 centrifugal and displacement-type pumps installed in BWRs which are required to perform a specific function in shutting down the reactor or in mitigating the consequences of an accident, and provided with an emergency power source, must undergo routine in-service inspection per ASME Boiler and Pressure Vessel Code, Section XI, Article IWP-1000. These quarterly tests are in addition to the Technical Specification surveillance requirements intended to demonstrate compliance with the plant safety analyses. The Section XI tests are intended to detect changes in pump performance. Article IWP-1500, "Detection of Change," states:

> "The hydraulic and mechanical condition of a pump, relative to a previous condition, can be determined by attempting to duplicate, by test, a set of basic reference parameters. Deviations detected are symptoms of changes and, depending upon the degree of deviation, indicate need for further tests or corrective action."

The in-service tests measure speed, if variable speed, inlet pressure, differential pressure, flow rate, and vibration amplitude. Alert ranges and required action ranges are strictly defined and require either increased frequency of testing or declaring the pump as inoperative, respectively. Performance outside of the required action range would place the affected system in a Limiting Condition for Operation.

Although these tests themselves would not detect pump dead-heading or inadequate minimum flow (since these are intended to be full flow tests), any deleterious effects of operating with inadequate flow would be detected in advance of significant pump performance degradation. Therefore, any changes in pump performance would be detected and corrected per routine pump testing in advance of pump degradation due to cumulative low flow effects from pump surveillance testing and normal system starts.

B. The potential for pump excessive wear attributable to minimum flow operation and/or dead-heading is negligible, since system operation in the minimum flow mode is limited to surveillance testing and during system start on a LOCA signal.

C. BWR operating experience indicates that short term operation in the minimum flow mode and/or dead heading has little or no impact on pump life. Pumps continue to function normally after such operations.

D. Pump wear attributable to minimum flow and/or dead-heading is not a significant contributor to total system unavailability. Other factors (such as loss of emergency power, loss of cooling, etc.) are more significant. BWR operating history indicates no occurrences of system unavailability due to pump excessive wear attributable to low flow operation.

E. For the LPCI/RHR and core spray pumps, the only design basis events that would lead to pumps running in the minimum flow mode and/or dead-heading are events that result in an ECCS initiation signal while the reactor is at high pressure (above the pump shutoff head). These events are normally small break LOCAs and loss of drywell cooling isolation events. Of these, only certain small break LOCAs actually require ECCS injection from LPCI/RHR or core spray after running at low flow.

Once initiated, the maximum duration that a LPCI/RHR or core spray pump may operate in the minimum flow mode for the spectrum of hypothetical LOCAs is less than 30 minutes. This is derived from postulated small break LOCAs, wherein reactor depressurization to below the shut-off head of these pumps is delayed. For large break LOCAs, where the full complement of ECC systems is more fully utilized, the reactor inherently depressurizes through the break. The present minimum flow bypass line is expected to provide adequate protection for these pumps for the short durations postulated during both the small and large break LOCAs.

For other scenarios, there is adequate time to secure the RHR and core spray pumps, and restart them as necessary, precluding extended operation in the minimum flow mode.

F. As discussed in Item E above, only certain small break LOCAs actually require ECCS injection for LPCI or core spray where the pumps may be operated in the minimum flow mode. However, because of the excess ECCS capacity that is available, limiting LOCA scenarios do not depend on both pumps of a pair of parallel pumps to operate in order to satisfy 10 CFR 50.46 requirements and General Design Criterion 35 of 10CFR50, Appendix A. In fact, a realistic LOCA analysis would show that only one low pressure ECCS pump is typically necessary to satisfy core cooling requirements during and following a LOCA.