August 8, 1988

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

D. S. CRUDEN
VICE PRESIDENT-NUCLEAR

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

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Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
NRC BULLETIN 88-04: POTENTIAL
SAFETY-RELATED PUMP LOSS

NRC Bulletin 88-04: "Potential Safety-Related Pump Loss" identified concerns with minimum flow designs and requested licensees to investigate these concerns and correct them where applicable. By our letter dated July 11, 1988, Virginia Electric and Power Company notified the Nuclear Regulatory Commission that potentially susceptible configurations did exist at North Anna, that evaluations were in progress, and that our response would be provided by August 8, 1988. Our response for North Anna Power Station is contained in Attachment 1. The Justification for Continued Operation is contained in Attachment 2. This Justification for Continued Operation has been approved by the Station Nuclear Safety and Operating Committee.

The information contained herein is true and accurate to the best of my knowledge. If you have any questions, please contact me.

Very truly yours,

D. S. Cruden

Attachment
1. North Anna Response
2. Justification for Continued Operation

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ADD:
TOM ALEXION

cc: U. S. Nuclear Regulatory Commission
101 Marietta Street, N.W.
Suite 2900
Atlanta, GA 30323

Mr. J. L. Caldwell
NRC Senior Resident Inspector
North Anna Power Station

COMMONWEALTH OF VIRGINIA)
)
CITY OF RICHMOND)

The foregoing document was acknowledged before me, in and for the City and Commonwealth aforesaid, today by D. S. Cruden who is Vice President - Nuclear, of Virginia Electric and Power Company. He is duly authorized to execute and file the foregoing document in behalf of that Company, and the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 8 day of August, 19 88.

My Commission expires: February 25, 19 90.

Vicki L. Hull
Notary Public

(SEAL)

ATTACHMENT 1
NORTH ANNA POWER STATION UNITS 1 AND 2
RESPONSE TO NRC BULLETIN 88-04:
POTENTIAL SAFETY-RELATED PUMP LOSS

I. SCOPE OF EVALUATION

As directed by NRC Bulletin No. 88-04, Virginia Electric and Power Company has investigated minimum flow recirculation design concerns in safety-related systems. These concerns are the potential for dead-heading of one or more pumps that have a minimum flow recirculation line common to two or more pumps or other piping configurations that do not preclude pump-to-pump interaction, and the adequacy of the minimum flow recirculation line for even a single pump in operation. Our investigation determined that the following systems were of possible concern:

A. Residual Heat Removal (RHR)
B. Low Head Safety Injection (LHSI)
C. Auxiliary Feed Water (AFW)

II. Summary of Conclusions and Problems

A. Residual Heat Removal (RHR)

1. The pump-to-pump interaction issue is not a concern since these pumps are only run individually by station procedures.

2. A single pump may, however, be run on recirculation for a significant period of time during system warm up or cool down and the minimum flow recirculation line is not adequately sized for extended operation on recirculation. (Note: the RHR system is not part of the ESF system.)

3. The RHR pumps are tested individually at least once during each cold shutdown, but not more frequently than once every three months. This testing is only for a short period of time and requires the pump discharge valve to be throttled, with system discharge valves open, to obtain at least 123 psi differential pressure, so that testing is not performed solely on minimum flow recirculation.

B. Low Head Safety Injection (LHSI)

1. The pump-to-pump interaction is not a concern based on the results of testing of similar pumps conducted at the Surry Power Station, and on an engineering evaluation of the specific recirculation piping arrangement at North Anna.

2. The LHSI pumps operate in parallel upon receipt of a Safety Injection signal. If the Reactor Coolant System pressure remains above the shutoff head for the LHSI pumps, they will operate on recirculation through a common minimum flow

recirculation line to the Refueling Water Storage Tank, and this line is not adequately sized for extended operation on recirculation. The recirculation line was sized based on thermal considerations rather than possible hydraulic instability phenomena which may exist.

3. The LHSI pumps are tested individually on miniflow recirculation for a short period (approximately 10 minutes) during quarterly performance testing. This testing frequency ensures that the requirements of the Technical Specifications and ASME Code Section XI are met, and that any pump degradation is detected and corrected in a timely manner.

C. Auxiliary Feed Water (AFW)

1. The pump-to-pump interaction issue is not a concern since the normal system alignment is for each pump to supply one steam generator and each pump has a minimum flow recirculation line with a flow restricting orifice before tie-in to a common header. However, after the steam generator water levels are returned to the desired level, the pumps can be operated at low flow/minimum flow recirculation for significant periods of time.

2. The motor-driven AFW pumps are also used to pressurize and leak-test the steam generators during maintenance outages.

3. The AFW pumps are tested individually on miniflow recirculation for a short period (approximately 10 minutes) during monthly performance testing. Yearly surveillance testing requires each pump to run on minimum flow recirculation for approximately 30 to 60 minutes to perform bearing temperature measurements. This testing frequency ensures that the requirements of the Technical Specifications and ASME Code Section XI are met, and that any pump degradation is detected and corrected in a timely manner.

III. Corrective Actions

A. Residual Heat Removal (RHR)

1. Short term - Appropriate procedures will be reviewed and revised, as necessary, by September 15, 1988 to minimize operation in the recirculation mode. Approved procedure deviations are currently in place to address this concern.

2. Long term - None required.

B. Low Head Safety Injection (LHSI)

1. Short term - Applicable Emergency Operating Procedures (EOPs) will be reviewed by November 1, 1988 to determine the need and feasibility of revising the procedures to reduce operation on minimum flow recirculation.

2. Long term

a. If our EOP review indicates that a procedure revision is necessary, we will provide these changes to Westinghouse for a generic review.

b. An evaluation by the pump vendor has been requested to determine the adequacy of the recirculation system. We will consider this information in deciding if future modifications are required.

C. Auxiliary Feed Water (AFW)

1. Short term

a. Appropriate procedures will be reviewed and revised, as necessary, by September 15, 1988 to minimize operation at low flow/minimum flow recirculation.

b. Appropriate post-maintenance test procedures will be revised by February 1, 1989 (prior to the next refueling outage) to limit the use of these pumps for leak-testing the steam generators.

2. Long term

a. One or more auxiliary feedwater pumps will be disassembled and inspected for degradation during each refueling outage for each unit so that all three pumps are inspected at least once every 3 years. If any inspection results indicate pump degradation, all of the affected unit's pumps will be inspected during the same outage.

b. Based on the results of the pump inspections and recommendations of the manufacturer, modifications to the minimum flow recirculation lines or an augmented pump inspection program will be considered.

IV. Justification for Continued Operation (JCO)

A JCO has been developed and approved by the Station Nuclear Safety and Operating Committee to justify continued operation pending final implementation of the short and long term corrective action. North Anna is currently operating in compliance with 10CFR50.46 and GDC-35. This evaluation is provided as Attachment 2.

ATTACHMENT 2
NORTH ANNA POWER STATION UNITS 1 AND 2
TECHNICAL EVALUATION - NRC BULLETIN 88-04
JUSTIFICATION FOR CONTINUED OPERATION

Virginia Electric and Power Company has reviewed the Nuclear Regulatory Commission Bulletin (NRCB) 88-04, "Potential Safety-Related Pump Loss," and has identified the Auxiliary Feedwater System (AFW), Residual Heat Removal System (RHR) and Low Head Safety Injection System (LHSI) as possibly affected by the problem described in the bulletin. This attachment is provided to establish the justification for continued operation of North Anna Units 1 and 2 based on this review.

The NRCB identified two concerns which could affect long term operation of the safety-related pumps. The first concern may occur when a strong/weak pump relationship exists in a system with parallel pumps and a common miniflow recirculation line. Under certain conditions the weaker pump may become deadheaded, resulting in damage. The second concern is inadequate recirculation during any operating or testing conditions which may result in reduced pump life.

Although the AFW system, RHR system, and LHSI system have been identified as requiring additional evaluation, continued operation based on the following discussion is justified for all conditions.

AUXILIARY FEEDWATER SYSTEM

Each of the three Auxiliary Feedwater Pumps (AFWP) has a separate recirculation line that joins to a common header leading to the Emergency Condensate Storage Tank (ECST). Each recirculation line contains a restriction orifice. The discharge of each pump is normally aligned to feed a separate steam generator for a loss of Feedwater, a Low-Low Steam Generator level, an undervoltage on the Reserve Station feed to the Emergency Busses, or a Safety Injection signal.

The original pump recirculation flow rates recommended by the pump manufacturer were based only on thermal rise considerations. The original recommended recirculation flows were 20 gpm for the motor driven pumps and 35 gpm for the turbine driven pumps. Recently the manufacturer raised these values to 135 gpm and 250 gpm respectively to protect the pumps against hydraulic instability as well as thermal rise. For the motor driven pumps this is 36.5% of BEP (best efficiency point for pump operation) and for the turbine driven pump 34% of BEP.

The Station Emergency Procedures require maintaining a total feed flow to the steam generators of greater than 340 gpm or greater than 10% steam generator level in at least one steam generator. When flowing at 340 gpm to the steam generators, the worst case minimum AFW pump flow would occur when all three AFW pumps are used to maintain the 340 gpm.

Assuming the 340 gpm was equally distributed between the three AFW pumps and taking into consideration the pump recirculation line flow, the motor driven pumps would both operate at 133 gpm and the turbine driven pump at 148 gpm. For the motor driven pumps, this represents 36% of the 370 gpm BEP. For the turbine driven pump, this is 20% of the 730 gpm BEP. The orifices in the individual recirculation lines would tend to minimize pump recirculation interaction when more than one auxiliary feedwater pump is operating. When cooling the reactor core from a temperature of 587°F to 350°F at a rate of 50° F/hr (at which time core cooling is continued using the residual heat removal system), this mode of operation could last for 5 hours. In this recovery scenario, the expected minimum flow rate for the motor driven pumps compares favorably with the current minimum flow recommended by the pump manufacturer. The flow rate for the turbine driven pump does not compare as well with current manufacturer recommendations.

In evaluating the 340 gpm flow situation, it is noted that any one of the three pumps is capable of providing the minimum required flow. The operator therefore has the option of securing up to two pumps. If used alone, the turbine driven pump would be operating at a minimum of 50% of BEP in this case.

Since the motor driven pumps are not instrumented to automatically shut down when 10% steam generator level is reached, the pumps could be operated on recirculation standby. Flow would be intermittently directed to the steam generators to provide make up for water that has boiled off. In order to ensure pump availability, all station operators will be made aware of the areas of concern using the required reading list and will be instructed to limit the time the pumps operate on recirculation.

The turbine driven pump is automatically controlled such that the pump starts operating on steam generator low-low level. When the acceptable level is reached, the pump shuts down. The pump automatically provides make up when needed and therefore is not required to operate on recirculation for long periods of time.

Based on the foregoing discussion regarding pump operation, operating the auxiliary feedwater pumps in parallel on recirculation is not expected to have detrimental effects on the pumps.

The AFWP's are tested in accordance with ASME Section XI in a miniflow recirculation mode on a monthly basis as required by the Technical Specifications. Once annually, an extended run (30-60 minutes) on recirculation is also conducted for bearing temperature stabilization testing. Testing the pumps on recirculation is performed such that the condition of the pumps is monitored to detect signs of potential pump degradation. When the pump test data does not conform with pre-established acceptance criteria, remedial action is taken.

Recirculation flows recorded from recent Periodic Tests meet or exceed original Vendor specified recirculation flow for both the turbine driven pump and motor driven pumps. Vibration measurements are also made during the pump performance test. This data is trended to detect bearing and major rotating element wear or damage.

To further insure system readiness, Technical Specification Section 4.7.1.2 also requires demonstration of flow to each steam generator from the respective AFWP during unit start-up from cold shutdown.

The accident analysis used as a basis for the original plant design requires only one motor-driven Auxiliary Feedwater Pump to be operating to maintain safe shutdown (UFSAR Section 10.4) provided the Reactor Coolant Pumps (RCPs) are secured. Two motor-driven or the one turbine-driven AFW pump would be required if the RCP's continued to operate. Shutdown of the RCP's is consistent with Emergency Operating Procedures providing additional assurance that component failure will not compromise safe shutdown of the plant.

Based on the foregoing discussion regarding pump testing and test data evaluation, the North Anna method of testing the auxiliary feedwater pumps on recirculation is not expected to reduce the reliability of the system to operate as designed when required.

RESIDUAL HEAT REMOVAL SYSTEM

The RHR system is designed to provide cooling of the reactor coolant system (RCS) when it is below 350°F and 418 psig. The RHR system contains two parallel pumps each with a BEP of 4000 gpm. The 3 inch minimum flow recirculation line has a capacity of 200 gpm. By procedure, the two pumps are not operated simultaneously.

Typically, the system is operated at greater than 3000 gpm. However, during system startup an individual pump may be operated on recirculation in order to warm up the RHR system prior to flowing to the RCS. Likewise, during system cooldown, the RHR pump is operated on recirculation while cooling down the RHR system.

In order to ensure the pumps are not operated on recirculation for an extensive period of time, a procedure deviation has been issued to administratively prevent operation on recirculation alone. The applicable operating procedure will be revised to reflect this change.

The RHR pumps are tested in accordance with ASME Section XI to ensure operability and to monitor the condition of the pumps to detect signs of potential pump degradation. Based on the method of operation and testing, the RHR pumps are not considered subject to degradation due to operation on recirculation.

LOW HEAD SAFETY INJECTION (LHSI)

The LHSI pumps operate in parallel upon receipt of a Safety Injection signal. If the Reactor Coolant System pressure remains above shutoff for the LHSI pumps, they will operate on recirculation through a common miniflow line to the Refueling Water Storage Tank. This line was sized for recirculation based on thermal considerations for the pumps.

Surry has performed flow testing on Unit 1 with their parallel LHSI pumps operating on recirculation to obtain data to determine if a strong/weak pump relationship exists. Based on these data it was determined that both pumps

had adequate recirculation flow to protect the pump and that neither pump was dramatically affecting the other.

The North Anna pumps are similar to those at Surry. However, the Surry pump recirculation lines join at a common header almost immediately adjacent to the pumps. In contrast, the North Anna piping arrangement is such that the pump recirculation lines meet at a common header which is a considerable distance from the pumps. For the North Anna design, it has been established by calculation that approximately 90 percent of the pressure drop which occurs in the pump recirculation lines occur before the lines join at the header. This design tends to minimize the effect that parallel pump operation would have on an individual pump.

The longest period during which the North Anna Unit 1 pumps were operated in parallel on miniflow recirculation was 49 minutes in 1979. Subsequent periodic tests and regular maintenance inspections have demonstrated that this event did not produce significant pump degradation.

The pumps are tested in accordance with ASME Section XI individually in recirculation during the quarterly Periodic Test. This testing is for short durations at flows of 240-270 gpm. These flows are above the 200 gpm stated by the vendor as acceptable for long term operation.

Recirculation testing therefore has not degraded pump performance to the extent that the reliability of the safety injection pumps is affected. Routine performance evaluation through the periodic testing program will continue to provide a reliable assessment that these pumps can perform their intended safety function.

CONCLUSIONS

The procedures used at North Anna for operating and testing the pumps in the AFW, RHR, and LHSI systems do not create an unreviewed safety question based on the evaluations described herein. The following considerations are noted in performing an analysis of the evaluation in terms of Unreviewed Safety Questions as defined by 10CFR50.59:

1) Does the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report increase?

   The probability of an accident or equipment malfunction is not increased due to operating and testing on recirculation as performed at North Anna. The method of operation is designed to ensure that the pumps remain fully operable. An operating directive has been issued to all licensed operators to minimize the time that the pumps are operated on recirculation. The pumps are regularly tested in accordance with ASME Section XI to verify operability and to detect signs of potential pump degradation.

2) Is the possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report created?

The possibility for an accident or malfunction of a different type than previously evaluated is not created due to operating and testing on recirculation as performed at North Anna. The method of operation is designed to ensure that the pumps remain fully operable. An operating directive has been issued to all licensed operators to minimize the time that the pumps are operated on recirculation. The pumps are regularly tested in accordance with ASME Section XI to verify operability and to detect signs of potential pump degradation.

3) Is the margin of safety as defined in the basis for any technical specifications reduced?

The margin of safety as defined in the basis for the Technical Specifications is not reduced due to operating and testing on recirculation as performed at North Anna. The method of operation is designed to ensure that the pumps remain fully operable. An operating directive has been issued to all licensed operators to minimize the time that the pumps are operated on recirculation. The pumps are regularly tested in accordance with ASME Section XI to verify operability and to detect signs of potential pump degradation. The requirements of the Technical Specifications will continue to be met.