DEC 2 4 1992

MEMORANDUM FOR: James A. Norberg, Chief
Mechanical Engineering Branch
Division of Engineering Technology
Office of Nuclear Reactor Regulation

FROM: Jack E. Rosenthal, Chief
Reactor Operations Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

SUBJECT: GENERIC IMPLICATIONS OF THRUST BEARING LOADING DURING LOW FLOW SURVEILLANCE TESTING OF PUMPS

Seabrook Station licensee event report (LER) 443/88-009-01 issued November 13, 1992 discusses increased thrust bearing loading for the residual heat removal system pumps when the pumps are run at reduced flows. I am concerned that inservice testing may: (1) not detect the problem soon enough to avoid the concern of a common-mode failure of the pumps or, (2) reduced flow may actually increase damage to the pumps. The same pumps are currently installed at Byron, Braidwood, Catawba, Vogtle and San Onofre Units 2 and 3. The concern may be applicable to other safety-related pumps.

It is my understanding that this issue is being reviewed as a Part 21, Log Number 92-256. The item has been assigned to the Reactor Systems Branch for evaluation.

A copy of the LER is attached for your information. If you have any questions, please call Earl Brown (492-4491) of my staff.

Original signed by Jack E. Rosenthal
Jack E. Rosenthal, Chief
Reactor Operations Analysis Branch
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data

Enclosure:
As stated 660097

cc w/enclosure:
Gordon E. Edison, NRR
Walter P. Haass, NRR

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NRC Form 366
(9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/88

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
SEABROOK STATION	0 5 0 0 0 4 4 3	1 OF 0 5

TITLE (4)
RESIDUAL HEAT REMOVAL (RHR) PUMP MODIFICATIONS TO REDUCE THRUST BEARING LOADING

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
1 2	0 8	8 8	8 8	0 0 9	0 1	1 1	1 3	9 2		0 5 0 0 0
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OPERATING MODE (9)	POWER LEVEL (10)	THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)			
5	0 0 0	20.402(b)	20.405(c)	50.73(a)(2)(iv)	73.71(b)
		20.405(a)(1)(i)	50.36(c)(1)	X 50.73(a)(2)(v)	73.71(c)
		20.405(a)(1)(ii)	50.36(c)(2)	50.73(a)(2)(vi)	OTHER (Specify in Abstract below and in Text, NRC Form 366A)
		20.405(a)(1)(iii)	50.73(a)(2)(i)	50.73(a)(2)(vii)(A)	
		20.405(a)(1)(iv)	50.73(a)(2)(ii)	50.73(a)(2)(vii)(B)	
		20.405(a)(1)(v)	50.73(a)(2)(iii)	50.73(a)(2)(x)	

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
Mr. James M. Peschel, Regulatory Compliance Manager, ext. 3772	AREA CODE 6 0 3 4 7 4 - 9 5 2 1

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS		CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	
B	B P	P	I 0 7 5	N							
B	B P	M O	W 1 2 0	N							

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
YES (If yes, complete EXPECTED SUBMISSION DATE)	X NO				

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On December 8, 1988, testing indicated that premature degradation of the Residual Heat Removal (RHR) pump thrust bearing could occur which would reduce its specified design life. This condition could result in the unanticipated shutdown of a system required to remove residual heat.

Long-term corrective action for this concern involved modification of the pumps to reduce the loading on the thrust bearings. This modification was developed by Westinghouse and Ingersoll-Rand based on testing of a Unit 2 pump in the original and modified configurations. The modification required a reduction in suction side wear ring inner diameter and impeller wear area outer diameter. Maintenance schedules have been developed to ensure thrust bearing replacement prior to the end of the current predicted service life.

There were no adverse safety consequences as a result of this condition. The RHR pumps remain capable of performing their safety function, despite decreased bearing life. The administrative controls ensure that sufficient bearing life remains to provide long-term post-accident cooling. Additionally, vibration monitoring will identify the onset of bearing deterioration prior to actual bearing failure.

This is the first occurrence of this type at Seabrook Station.

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On November 25, 1987, Residual Heat Removal (RHR) pump RH-P-8A was removed from service due to excessive vibration at a frequency range indicative of excessive thrust bearing wear. This occurrence was premature when compared to the expected life of the bearing (7300 hours versus 100,000 hours). Each Seabrook Station RHR pump consists of a Westinghouse vertical, 400 HP, frame 5009P39, motor installed on a close-coupled Ingersoll-Rand model 8X20WDF pump. The affected bearing was one of two thrust bearings located in the lower bearing housing of the motor. Both bearings are 40 degrees angular contact ball bearings mounted face-to-face. The failure occurred in the uppermost of the two bearings, i.e., the downward loaded thrust bearing.

In situ testing was performed to determine the actual thrust on both the A and B train RHR pumps. The measured thrusts significantly exceeded the specified maximum down thrust and closely correlated to the loads required to produce the observed bearing degradation. As a result of this testing, a decision was made to return one of the Seabrook Station Unit 2 RHR pumps to Ingersoll-Rand for further testing.

On December 8, 1988, testing was performed at Ingersoll-Rand on the Unit 2 RHR pump original design and on a modified configuration. This testing indicated that premature degradation of the Residual Heat Removal (RHR) [BP] pump thrust bearing could occur which would reduce its specified design life. This condition could result in the premature shutdown of a system required to remove residual heat. Corrective actions discussed below were developed by Westinghouse and Ingersoll-Rand to reduce RHR pump thrust bearing loading. As a result of these modifications, RHR pump bearing life is predicted to be 33,017 hours at 3500 gpm.

SAFETY SIGNIFICANCE

RHR pump performance is monitored quarterly as part of the ISI Program. A review of past performance data indicates that RHR pump characteristics (i.e., head and flow) did not degrade over time. Pump vibration monitoring provides additional assurance that the RHR pumps will continue to be capable of performing their required safety function. The "alert" and "required action limits" in the ASME Code Section XI insure that vibration will be corrected prior to severe pump damage.

Assuming the single failure of one train of RHR, the remaining RHR pump would not catastrophically fail as a result of bearing degradation. Rather, increased vibration in the operating pump would provide warning of degradation long before any impact on system performance would occur. Therefore, adequate time would exist to restore the alternate train or take other remedial measures prior to actual failure of the pump.

Degradation is also not likely to result in simultaneous failure of both trains. The lower thrust values recorded on the B pump resulted in considerably longer bearing life for this pump. The differences in thrust values, point in service life, and previous operating history make a simultaneous failure unlikely.

The safe shutdown capability of the ECCS is not impaired as a result of reduced bearing life. Since bearing degradation is a slow process, the engineered safety features of the plant would perform normally. After transfer to recirculation or long term RHR cooling, the RHR pump

bearing may begin to degrade. Sufficient time would exist to take corrective action to ensure that the redundant pump is operable and capable of performing the long-term cooling function while repairs are made to the degraded pump.

CORRECTIVE ACTIONS

The RHR pumps have been modified as discussed below to reduce the loading on the thrust bearings. The modifications were developed by Westinghouse and Ingersoll-Rand based on testing conducted at Ingersoll-Rand in December 1988 on a Unit 2 RHR pump. The Ingersoll-Rand testing was performed on the Unit 2 pump original design and on a modified design. The modified design resulted in a significant reduction in thrust bearing loading. The Unit 1 RHR pumps were modified based on the recommendations of Westinghouse and Ingersoll-Rand and in-situ measurements of thrust bearing loading were performed. The in-situ thrust bearing measurements indicated that loading was not reduced to the extent determined by Ingersoll-Rand, however, loads were sufficiently reduced, extending the predicted life of the thrust bearings to 33,017 hours at 3500 gpm. Replacement of the thrust bearings will be made prior to exceeding 24,257 hours of service at 3500 gpm so as to maintain a one year reserve life in the unlikely event of an accident at the predicted end of service life. A detailed discussion of the corrective actions is provided below.

The RHR pump design requirements are found in Westinghouse E Spec. 952470, Rev. 2 (FP50279, Issue 12). This document specifies that the bearings are to have a Rating Life of B10 as calculated in AFBMA Standard 9, dated June 1972, and be suitable for a minimum of 100,000 hours of service.

To achieve design compliance, utilizing the existing bearing, (type 7222 BEAGY), externally applied loads which contribute to downthrust must be reduced to 1700 lbs. These externally applied loads are the net result of hydraulic forces acting upon the impeller during operation of the pump. In the original pump design, the net force has been lowered by employment of five, 9/16" diameter, balancing holes drilled in the impeller which reduce the pressure being applied. Close tolerance running clearances are also employed to help maintain pressure differentials applied across the impeller.

Ingersoll-Rand was contracted by Westinghouse to measure the impeller axial thrust using load cells between the motor and the motor support head. The results of the tests performed before and after impeller and wear ring modifications are presented in Ingersoll-Rand Technical Report TR-8808, dated 12/22/88. A copy of Ingersoll-Rand Technical Report TR-8808 is available for review at Seabrook Station. The test results were provided to Westinghouse and formed the basis for issuance of Westinghouse Field Change Notice FCN-10588, and Westinghouse supporting analysis documented in Safety Evaluation Check List (SECL) No. 89-001. A copy of these documents are available for review at Seabrook Station.

The Ingersoll-Rand test results verify that a reduction in the front ring diameter was effective. Peak hydraulic thrust (occurring at 2300 gpm) was reduced from 5300 lbs. to 3100 lbs. Dependent on flow, a dramatic reduction in hydraulic thrust load was seen, at and beyond 3000 gpm. The modified configuration thrust at 3000 gpm as measured by Ingersoll-Rand was recorded to be 1376 lbs.

Pump performance was monitored and recorded during the Ingersoll-Rand test. Westinghouse has reviewed this data against the manufacturers certified performance test curve, and has determined pump performance to be virtually unchanged. System flow and NPSH calculation therefore, were not affected by this change.

Westinghouse in conjunction with Ingersoll-Rand developed the design modification specified in FCN-10588. The modification reduces downthrust by increasing forces acting up on the impeller. To accomplish this, the suction side wear ring inner diameter and impeller wear area outer diameter were reduced, thus increasing the surface area (outside the wear ring) over which the higher discharge pressures are applied. The corresponding reduction of area inside the suction wear ring reduces uplift applied by suction pressure. Since the magnitude of force applied by discharge pressures are significantly greater a net increase in uplift will result. Peak hydraulic thrust loads were not reduced to the original design value of 1700 lbs; thus, Westinghouse/ Ingersoll-Rand recommended that the specified bearing life of 100,000 hours be revised to reflect the expected bearing life with the modified impeller/wear ring. Westinghouse/Ingersoll-Rand predicted that when operating at peak thrust (approximately 2300 gpm), a bearing life of 28,560 hours is predicted and that operation at flow rates greater than 2800 gpm can extend predicted life to 74,700 hours due to the reduction of loads in this range. These predictions are based on prototype modification test data. Actual bearing life predictions to be used in determination of bearing replacement at Seabrook Station were determined based on post implementation in-situ testing discussed below.

Westinghouse recommended that the RHR pump flow controller nominal setpoint be increased from the current 3000 gpm to a value between 3200 and 3300 gpm. Based on in-situ test results operation at a flow controller setpoint of 3500 gpm is required to offer an appreciable reduction in thrust loads. Westinghouse concurred that operating at 3500 gpm is acceptable, except during mid loop operation and that adequate NPSH will exist at the higher flow.

Bearing replacement will be made at the predicted bearing life less one year post-accident reserve life. Although SECL-89-001 utilizes a 100 day reserve in calculation of the replacement interval example, the thrust bearing replacement schedule utilized by North Atlantic will ensure RHR pump operability for a postulated post-accident duration of one year.

The predicted bearing life, established in SECL-89-001, is based on thrust load data collected during prototype testing of the RHR pump modification. Bearing replacement intervals to be used at Seabrook Station are based on post implementation in-situ test data collected on the installed pumps. These post implementation thrust data results are documented in Teledyne Report TR-20834 (885), showing less reduction in thrust load than that determined by Ingersoll-Rand. The Teledyne Reports (September 7, 1989, for RHR Pump 8A and January 5, 1990 for RHR Pump 8B) are available for review at Seabrook Station.

Operation of the RHR pumps at 3500 gpm will provide the lowest achievable thrust load within an acceptable operating band for the pumps. Operating procedures have been revised to require operating flowrates of 3500 gpm during normal RHR system operation, except during mid loop operation.

To predict the service life of the thrust bearing, North Atlantic utilized the highest hydraulic load established during the in-situ test of 2775 lbs (extrapolated from pump 8A data at 3500

gpm) and added the test data tolerance (400 lbs) and rotating element weight (950 lbs) to establish a total bearing load of 4125 lbs. North Atlantic calculated the predicted bearing life (using equations and bearing data from SKF Bulletin 213-715, Sept. 1985) as 33,017 hours.

The predicted life (33,017 hrs.) has been reduced by one year to ensure reserve life in the unlikely event of an accident at or near the end of predicted life.

North Atlantic has determined that replacement shall be made after 24,257 hours of service at 3500 gpm and has established the controls necessary to determine when replacement is necessary based on a cumulative account of operating hours. Should mid loop operation become necessary with its lower required flow rates, North Atlantic will determine the bearing life expended during that period using the in-situ test data and reestablish remaining life.

There were no adverse safety consequences as a result of this condition. The RHR pumps remain capable of performing their safety function, despite decreased bearing life. Administrative controls ensure that sufficient bearing life remains to provide long-term post-accident cooling. Additionally, vibration monitoring will identify the onset of bearing deterioration prior to actual bearing failure.

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NYN-92160

November 19, 1992

United States Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Document Control Desk

References: (a) Facility Operating License No. NPF-86, Docket No. 50-443

(b) North Atlantic Letter NYN-89006 dated January 9, 1989, "Licensee Event Report (LER) No. 88-009-00: Premature Residual Heat Removal (RHR) Pump Thrust Bearing Failure," G. S. Thomas to USNRC

Subject: Licensee Event Report (LER) No. 88-009-01: Residual Heat Removal (RHR) Pump Modifications to Reduce Thrust Bearing Loading

Gentlemen:

Enclosed please find Licensee Event Report (LER) No. 88-009-01 for Seabrook Station. This submittal provides supplementary information regarding modifications to the Seabrook Station Residual Heat Removal (RHR) pumps which have been implemented to reduce loading on the RHR pump thrust bearings to extend their service life.

Should you require further information regarding this matter, please contact Mr. James M. Peschel, Regulatory Compliance Manager, at (603) 474-9521 extension 3772.

Very truly yours,

Ted C. Feigenbaum

TCF:ALL/act

Enclosures: NRC Forms 366, 366A

200046

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