UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

March 9, 1995

NRC INFORMATION NOTICE 95-16: VIBRATION CAUSED BY INCREASED RECIRCULATION FLOW IN A BOILING WATER REACTOR

Addressees

All holders of operating licenses or construction permits for boiling water reactors (BWRs).

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to the potential for resonance vibration caused by an increase in reactor coolant recirculation flow rates. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances

On June 21, 1994, the operators at Susquehanna Steam Electric Station Unit 2 raised the reactor coolant recirculation flow rate from the normal rate of about 45 Mkg/hr [100 Mlb/hr] to 49 Mkg/hr [108 Mlb/hr] as part of a testing program for an approved uprate in reactor power. The following day, with the recirculation pump speed at 1570 to 1580 rpm (95 percent), the operators noted a number of abnormal indications of significant vibration. These included vibration of the containment instrument gas piping outside the containment and vibration of the suppression pool hatch covers. The operators in the control room noted a low-frequency pulsating hum, which appeared to be coming from the primary containment structure.

The licensee attributed the excessive vibration to the increased speed of the recirculation pumps. Consequently, on June 23 the operators systematically lowered the pump speed while monitoring the vibration. When the speed of both of the recirculation pumps was lowered to 1515 rpm, the vibration and noise levels returned to normal. The licensee estimated that the vibration had persisted for approximately 18 hours, although it was not clear then at what time and flow rate the vibration actually started. The licensee performed a thorough evaluation of the effects of the vibration on the plant and concluded that it had not caused any damage. The licensee also concluded that maintaining the recirculation pumps at 1515 rpm, with a resulting flow rate of 46.7 Mkg/hr [103 Mlb/hr], was acceptable and administratively limited the recirculation pumps to this speed.

The licensee conducted a second increased reactor recirculation flow test program on Unit 2 during the second week in December 1994, increasing the flow rate in steps from 46.7 Mkg/hr [103 Mlb/hr] to 49 Mkg/hr [108 Mlb/hr]. At each pump speed plateau, the licensee deliberately varied the speed difference between the two pumps from 0 to 2 percent of the average pump speed. When the flow rate reached 47.6 Mkg/hr [105 Mlb/hr], the vibration noise phenomena reappeared with the most pronounced effect occurring with a difference in speed between the two pumps of 2 percent.

Discussion

The licensee has concluded that the vibration was caused by pressure pulses emitted from the recirculation pumps as the pump impeller vanes passed the pump openings. These pulses were amplified by an as yet undefined resonating mechanism. The pumps are manufactured by Byron Jackson. They are of the centrifugal type and have five vane impellers. The 1570-rpm to 1580-rpm pump speed when multiplied by the number of vanes corresponds to the measured 131 Hz frequency of the vibration that was measured at the suppression pool hatch covers. This frequency also correlates well with the natural frequency of the hatch covers, which was measured to be 133 Hz. The low-frequency modulation is caused by a slight difference in the frequency of the two recirculation pumps, causing the two pumps to alternately go in and out of synchronization with respect to vane passage of the respective pump openings. As this occurs, the vane-generated pressure pulses tend to alternately reinforce and cancel each other, resulting in a modulation of the frequency.

The licensee has established a working group to identify the vibration-amplifying mechanism. It is coordinating this investigation with General Electric, the reactor supplier. The NRC staff will continue to monitor the investigation.

Vibration attributable to high recirculation flow has been noted at several nuclear power plants in the past. Hope Creek has experienced excessive vibration on several occasions when the reactor recirculation flow was above 47.4 Mkg/hr [104.5 Mlb/hr]. On September 18, 1987, excessive vibration caused two leaks from the recirculation flow instruments. The Hope Creek licensee now monitors the recirculation system for excessive vibration during end-of-cycle coastdown periods and, if excessive vibration is detected, reduces recirculation flow.

In the fall of 1989, Quad Cities Unit 2 experienced a harmonic vibration during reactor recirculation system coastdown tests when the pump speed passed 420 rpm. The licensee attributed the vibration to the vane passing frequency excitation phenomenon and established an administrative limit on recirculation flow to minimize the possibility of a recurrence.

In September 1992, the Browns Ferry Unit 2 licensee increased the recirculation pump speed in preparation for an end of cycle coastdown. The reactor experienced a resonant vibration when the recirculation pump speed was near 1500 rpm. The licensee administratively limited the pump speed to less than this value.

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

Brian K. Grimes, Director
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Office of Nuclear Reactor Regulation

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Attachment:
List of Recently Issued NRC Information Notices

Attachments filed in Jacket

LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
95-15	Inadequate Logic Testing of Safety-Related Circuits	03/07/95	All holders of OLs or CPs for nuclear power reactors.
95-14	Susceptibility of Containment Sump Recirculation Gate Valves to Pressure Locking	02/28/95	All holders of OLs or CPs for nuclear power reactors.
95-13	Potential for Data Collection Equipment to Affect Protection System Performance	02/24/95	All holders of OLs or CPs for nuclear power reactors.
95-12	Potentially Nonconforming Fasteners Supplied by A&G Engineering II, Inc.	02/21/95	All holders of OLs or CPs for nuclear power reactors.
95-11	Failure of Condensate Piping Because of Erosion/ Corrosion at a Flow-Straightening Device	02/24/95	All holders of OLs or CPs for nuclear power reactors.
95-10 Supp. 1	Potential for Loss of Automatic Engineered Safety Features Actuation	02/10/95	All holders of OLs or CPs for nuclear power reactors.
95-10	Potential for Loss of Automatic Engineered Safety Features Actuation	02/03/95	All holders of OLs or CPs for nuclear power reactors.
95-09	Use of Inappropriate Guidelines and Criteria for Nuclear Piping and Pipe Support Evaluation and Design	01/31/95	All holders of OLs or CPs for nuclear power reactors.
95-08	Inaccurate Data Obtained with Clamp-On Ultrasonic Flow Measurement Instruments	01/30/95	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit

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orig /s/'d by BKGrimes

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DOCUMENT NAME: 95-16.IN

* See previous concurrences

OECB:DOPS*	PUB:ADM*	EMEB:DE*	PDI-1:DRPE*
DKirkpatrick	MMejak (Tech Ed)	PYChen	CPoslusny
10/12/94	10/13/94	11/8/94	10/18/94
C/EMEB:DE*	D/DE*	OECB:DOPS*	SC/OECB:DOPS*
RWessman	BSheron	TGreene	EGoodwin
01/29/95	02/08/95	02/13/95	02/21/95
OECB:DOPS*	C/OECB:DOPS	D/DOPS	
RKiessel	AChaffee*	BGrimes	
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