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

March 18, 1988

NRC INFORMATION NOTICE NO. 88-09: REDUCED RELIABILITY OF STEAM-DRIVEN AUXILIARY FEEDWATER PUMPS CAUSED BY INSTABILITY OF WOODWARD PG-PL TYPE GOVERNORS

Addressees:

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose:

This information notice is provided to alert addressees to continuing problems affecting the reliability of steam-driven auxiliary feedwater pumps caused by instability problems with Woodward governors. It is expected that recipients will review the information for applicability to their facilities and consider actions, if appropriate, to avoid similar problems. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

The steam-driven auxiliary feedwater pumps at Calvert Cliffs are powered by Terry steam turbines (GS-2N) with Woodward PG-PL type governors. Before July 23, 1987, periodic surveillance testing of the steam-driven auxiliary feedwater pumps (AFWPs) was preceded by a warmup of the turbines before initiation of the quick startup tests. On July 23, 1987, during a loss-of-offsite-power event, the number 11 AFWP on Unit 1 tripped on its initial demand as a result of turbine overspeed. To ensure that future periodic (monthly) surveillance testing of the turbine-driven AFWPs would be conducted under more realistic conditions, the test procedures were modified to require quick starts from cold conditions. During subsequent tests in July through October 1987, a number of trips of the steam-driven AFWPs occurred at Calvert Cliffs. On July 30, 1987, during rapid cold startup testing, both of the Unit 2 steam-driven pumps tripped. On September 26, 1987, the number 11 AFWP on Unit 1 began oscillating after the initial startup attempt and subsequently tripped on overspeed. On October 23, 1987, the number 12 AFWP on Unit 1 tripped on overspeed.

The licensee conducted an intensive testing and troubleshooting program to determine the causes of the failures. During these tests, a number of test

failures were experienced because of turbine governor oscillation and overspeed. The most frequent failure sequences were either rapid initial acceleration of the turbine to the overspeed trip point, or large undamped speed oscillations that increased in magnitude to the overspeed trip point. Less frequently, trips occurred when the mechanical latch mechanism holding the trip valve open (which appeared to be overly sensitive) tripped. Subsequent attempts to test the pumps immediately after initial steam-driven AFWP failures were normally successful.

Discussion:

Several factors were identified which appear to have contributed to the reduced reliability of the AFWPs. These include:

1. Use of governor buffer springs of less than optimal stiffness, resulting in the inability of the governor to dampen out upset conditions. One of the installed governors and all three of the spare governors had buffer springs of a lower stiffness than that listed in the procurement specification on file at the Woodward company.

2. Excessive condensate trapped in the steam supply lines, resulting in governor valve damage, governor linkage damage, and throttle control instabilities as slugs of water hit the governor valve and turbine wheel.

3. Improperly adjusted and degraded governor linkage, resulting in excessive linkage play.

4. Governor valve binding, resulting in governor actuator over-reaction to small feedback signals.

5. A failed governor on the Unit 2, number 22 AFWP.

6. Damaged and misaligned overspeed trip mechanisms, resulting in oversensitivity to vibration, jarring, and waterhammer.

The licensee implemented several corrective actions and plans additional upgrades. These are described below.

1. Stiffer buffer springs were installed in the governors of all AFWPs to increase control system dampening at the expense of increased control system response time.

2. Upgrading of both the procedures and the systems was initiated, which included more thorough drain procedures and drain lineup verification. The interval for manually draining the steamlines and turbine casings was decreased from every 8 to every 4 hours. Additional manual drains were installed in the system low points to eliminate water from the steamlines.

3. Various parts of the governor valves, governor linkages, and trip linkages were overhauled, adjusted, and replaced. Trip linkages associated with

the overspeed mechanisms and the trip throttle valves were adjusted to increase trip latch engagement and thereby reduce sensitivity to physical shock. For some parts, such as linkage plates (cams), it was necessary for the utility to obtain the special materials involved and fabricate replacement parts in house.

4. Further steamline drain improvements are being evaluated.

The Calvert Cliffs problems highlight the importance of optimally sizing buffer springs, since the single, most effective short-term corrective action appeared to be installation of the stiffer buffer springs. However, changes in spring stiffness for the purpose of improving stability can adversely affect other governor response characteristics. Therefore, the selection of optimal spring stiffness should be carefully considered. In addition, it is important to ensure maintenance of proper spring stiffness following initial determination of optimal stiffness. In the case of Calvert Cliffs, the addition of stiffer springs appeared to provide an extra margin of stability. This temporarily compensated for other auxiliary feedwater system deficiencies that also required correction.

Reliability problems were much more evident when the auxiliary feedwater pumps were periodically tested using quick starts from cold conditions. This demonstrates the importance of surveillance testing which, in so far as practical, duplicates the service conditions that would exist if the equipment were called on to operate.

Information Notice 86-14, "PWR Auxiliary Feedwater Pump Turbine Control Problems," and 86-14, Supplement 1, "Overspeed Trips of AFW, HPCI, and RCIC Turbines," discuss problems closely related to those discussed in this information notice.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the technical contact listed below or the Regional Administrator of the appropriate NRC regional office.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contact: D. Limroth, RI
(215) 337-5121

Attachment: List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED
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86-81, Supp. 1	Broken External Closure Springs on Atwood & Morrill Main Steam Isolation Valves	1/11/88	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
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4. Further steamline drain improvements are being evaluated.

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