UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

September 24, 2010

NRC INFORMATION NOTICE 2010-20: TURBINE-DRIVEN AUXILIARY FEEDWATER PUMP REPETITIVE FAILURES

ADDRESSEES

All holders of an operating license or construction permit for a nuclear power reactor issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees of recent operating experience involving repetitive failures of turbine-driven auxiliary feedwater (TDAFW) pumps. The lessons learned from these events may apply to turbine-driven pumps in other systems such as reactor core isolation cooling and high-pressure coolant injection systems. The NRC expects recipients to review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. The suggestions in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

<u>Fort Calhoun Station</u>

On February 17, 2010, the TDAFW pump at the Fort Calhoun Station (Fort Calhoun) failed a surveillance test when it tripped on high turbine exhaust backpressure approximately 20 seconds after starting. In the unique design of the Coffin turbine pump at Fort Calhoun, the turbine has an exhaust backpressure trip mechanism consisting of a trip piston that is actuated from the turbine exhaust line that actuates a trip latch and reset lever. A high exhaust backpressure causes the trip piston to extend and push up on the trip latch, unlatching it from the reset lever. The reset lever, through linkages, depressurizes the TDAFW pump control oil pressure and closes the turbine steam inlet valve.

In five instances between 2001 and 2010, the licensee found that the trip latch had unlatched from the reset lever, most likely due to personnel working near the backpressure trip mechanism bumping into the latch. However, the licensee's actions to understand the cause and prevent additional instances of the mechanism unlatching were ineffective. When the mechanism becomes fully unlatched, a control room alarm alerts operators to the condition. The licensee had not recognized that the mechanism was susceptible to a partial unlatched

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condition in which sufficient engagement of the trip latch and reset lever existed to prevent the actuation of the alarm but not enough to prevent the TDAFW pump from tripping when started.

In light of the February 17, 2010, failure, the licensee reexamined two other recent failures of the TDAFW pump that occurred on February 26, 2009, and April 6, 2009. The licensee was unable to duplicate the exact conditions that caused any of these three failures. Instead, the most likely root cause of the events was determined from data collected during the failure analysis that occurred following each of the pump trips.

The cause of the first failure, on February 26, 2009, was air entrainment in the pump oil system, following a maintenance activity from earlier that day. A high point in the oil system was created during the oil tubing replacement modification in 2001. The licensee was not aware that air could collect in the high point of the oil system and affect the starting of the pump, and therefore provided no procedural guidance for ensuring that air was vented following maintenance that affected the tubing. The April 6, 2009, TDAFW pump trip was due to an actuation of the pump high discharge pressure switch. Following a pump configuration change on February 26, 2009, the operating discharge pressure of the pump was much closer to the high discharge pressure setpoint. The licensee did not sufficiently account for the even higher discharge pressure that occurs during pump startup.

The three TDAFW pump failures resulted from inadequate design changes or involved an insufficient understanding of the control systems and the baseline transient performance characteristics of the turbine. Both internal and industry operating experience were available, and if properly analyzed and applied could have prevented the pump trips. Following a comprehensive review of the three trips, the licensee took corrective actions, which included providing additional training for engineering personnel on the control systems for the TDAFW pump. They also took actions to prevent the inadvertent bumping of the TDAFW pump backpressure trip mechanism.

Additional information is available in Fort Calhoun/NRC Special Inspection Report 05000285/2010-006, dated August 12, 2010, and can be found on the NRC's public Web site under Agencywide Documents Access and Management System (ADAMS) Accession No. ML102250215.

Robert E. Ginna Nuclear Power Plant

On December 2, 2008, the TDAFW pump at the Robert E. Ginna Nuclear Power Plant (Ginna) failed a surveillance test when it was unable to develop the acceptable minimum discharge flow and pressure. Following review of the incident, the licensee determined that binding of the governor control linkage caused the failure. The binding occurred because the licensee had incorrectly removed the task of cleaning and lubricating the linkage from the work scope of the previous maintenance window.

On May 26, 2009, the TDAFW pump tripped on overspeed during a surveillance test. The licensee replaced several components in the pump's lube oil system and adjusted the governor valve linkage. However the licensee had not yet completed their root cause evaluation to identify the definitive cause for the pump trip when the TDAFW pump again tripped on overspeed during a surveillance test on July 2, 2009. The licensee evaluation determined that the stem of the governor control valve had become bound to its bushing because of corrosion buildup.

In April 2005, the licensee found corrosion on the stem of the governor control valve during a routine scheduled maintenance inspection and replaced the valve stem as part of the maintenance activity, but took no further action to determine the cause of the corrosion. In July 2005, the licensee identified that the TDAFW pump steam admission valves were leaking. Attempts to stop the leakage by cycling the valves in October 2006 and attempts to rebuild the valves during the subsequent refueling outage reduced the leakage but were unsuccessful at completely stopping it. At this time, the licensee did not make the connection between the leaking steam admission valves and the earlier corrosion on the stem of the governor control valve; therefore, it took no measures to increase the frequency of inspections and maintenance on the governor control valve stem. The NRC conducted a special inspection of this event and determined that the corrosion on the governor valve stem was the likely cause of the May 26, 2009, surveillance test failure and may have contributed to the December 2, 2008, failure.

The NRC issued IN 94-66, "Overspeed of Turbine-Driven Pumps Caused by Governor Valve Stem Binding," on September 19, 1994, and IN 94-66, Supplement 1, "Overspeed of Turbine-Driven Pumps Caused by Binding in Stems of Governor Valves," on June 16, 1995 (ADAMS Accession Nos. ML031210648 and ML031060370, respectively) to describe binding in the stems of governor control valves caused by corrosion that has been accelerated by leaking steam admission valves. When the licensee first encountered corrosion on the stem of the governor control valve in 2005, they missed the opportunity to use previous operating experience to help fully resolve the problem. The licensee inspected and reworked the steam admission valves and the governor control valve and enhanced its TDAFW surveillance program. To further address the issue, the licensee worked with the original equipment manufacturer to redesign the governor control valve to be less susceptible to corrosion. Additional information is available in Ginna/NRC Special Inspection Team Report 05000244/2009008, dated November 12, 2009, and on the NRC's public Web site under ADAMS Accession No. ML093160122.

Tihange Nuclear Power Station, Unit 2 (Belgium)

During a 5-month period beginning in October 2005, Tihange Nuclear Power Station, Unit 2, experienced three overspeed trips of the TDAFW pump; the second and third trips occurred during demand starts following a reactor trip. After the first two pump trips, plant personnel attributed the excessive moisture accumulation in the turbine during the turbine start as the cause of the overspeed trip. However, the plant initiated a more comprehensive analysis only after the third trip. Further tests indicated a lack of synchronization in the operation of the steam inlet valve and the speed regulation valve. Plant personnel also noted that the accumulation of moisture was strongly dependent on the external temperature. The plant addressed this moisture accumulation issue by adding insulation, adjusting the opening times of the steam inlet valve and speed regulating valve, and increasing the surveillance frequency from quarterly to daily. As surveillances were successfully completed, the plant gradually relaxed the frequency to the previous quarterly schedule.

The pump functioned properly until it tripped on overspeed during a surveillance test on October 16, 2006, and on October 30–31, 2006. Plant personnel noted that the external temperature on these days was much colder than usual, but took no other actions except to establish an auxiliary feedwater working group in early 2007.

In September 2008, the pump failed to start during its quarterly surveillance when the steam inlet valve failed to open. Plant personnel performed testing and replaced the packing for the steam inlet valve, but the surveillance failed two more times in October 2008. They then identified a failed spring in the pneumatic servomotor of the steam inlet valve. Replacing the spring was effective in correcting the overspeed trip problem.

Plant personnel addressed the direct causes of the pump failure several times but failed to identify the possible underlying causes of the failures. If the plant had followed a recommendation, made after the first series of failures, to install instrumentation to monitor the transient behavior of the steam inlet valve, it might have been possible to identify the problem earlier. However, this recommendation was not implemented before plant personnel resolved the issue. The plant has since determined that establishing a multidisciplinary working group to address failures of complex safety systems is a successful approach for determining the root cause of the failure and for making appropriate changes to maintenance, surveillance, and training programs to ensure the continued availability and reliability of the system.

DISCUSSION

This IN discusses operating experience involving repetitive failures of TDAFW pumps—risk-significant components that must be operable as specified in technical specifications. The licensees in the above examples did not meet Criterion XVI, “Corrective Action,” of Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” to 10 CFR Part 50, which requires licensees to establish measures to “assure that conditions adverse to quality” be “promptly identified and corrected.” This failure in the area of problem identification and resolution by both licensees resulted from a failure to properly implement their corrective action program.

The above examples illustrate the importance of ensuring that any condition adverse to quality affecting the TDAFW system is fully understood so that appropriate corrective actions can be taken. Repetitive failures, even if the physical failure mechanisms are different, may indicate that although the direct cause of the original condition was addressed, the root cause remains uncorrected. A thorough review of previous industry operating experience, not only for TDAFW systems but also for turbine-driven pumps in the reactor core isolation cooling and high-pressure coolant injection systems, can assist in determining a course of action. Likewise, a thorough knowledge of plant operating experience, including the expected baseline characteristics of the systems, may allow the licensee to diagnosis impending problems before a failure actually occurs. A multidisciplinary root cause analysis that explores all possible causes of the failure, not only to determine what actually failed but also to determine how that failure may have occurred, could be especially useful for cases of intermittent or seemingly unconnected failures that have different direct causes but may have a deeper, unresolved problem. Corrective actions that address not only the failed component but also the inadequate processes that allowed the component to fail are more likely to be effective in preventing recurrence.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contact listed below or to the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

/RA/

Timothy J. McGinty, Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contact:	Rebecca Sigmon, NRR	Michael Chambers, RIV
	301-415-4018	402-825-5657
	E-mail: Rebecca.Sigmon@nrc.gov	E-mail: Michael.Chambers@nrc.gov

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