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

August 26, 1991

NRC INFORMATION NOTICE NO. 86-14, SUPPLEMENT 2: OVERSPEED TRIPS OF AFW, HPCI AND RCIC TURBINES

Addressees:

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

Purpose:

This information notice supplement is intended to alert addressees to a recently identified condition in which turbine-driven pumps may trip on overspeed because of the sluggish response of the turbine speed governor caused by an accumulation of dirt and grit in the governor's control oil system. Recent overspeed trips of turbine-driven pumps have also prompted the staff to issue this supplement to reemphasize previously identified causes of overspeed trips. 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 supplement do not constitute NRC requirements; therefore, no specific action or written response is required.

Background:

On March 10, 1986, the NRC issued Information Notice (IN) 86-14, "PWR Auxiliary Feedwater Pump Turbine Control Problems," to alert addressees to certain conditions that could cause turbine-driven pumps to trip on overspeed. In August 1986, the NRC Office for Analysis and Evaluation of Operational Data (AEOD) issued study AEOD/C602, "Operational Experience Involving Turbine Overspeed Trips." On December 17, 1986, the NRC issued IN 86-14, Supplement 1, "Overspeed Trips of AFW, HPCI and RCIC Turbines," which summarized the results of the AEOD study.

Recent operating experience has shown that overspeed trips of turbine-driven pumps continue to occur from the same basic causes identified in the AEOD report. A description of recent operating experience and a newly identified condition follows.

Description of Circumstances:

On November 13, November 29, and December 6, 1990, during three separate operational tests of the turbine-driven auxiliary feedwater (AFW) pump at Arkansas Nuclear One (ANO), Unit 2, the turbine tripped on overspeed during

initial acceleration. After each of the three overspeed trips, the licensee manually reset and successfully started the turbine several times. After the third overspeed trip, the licensee determined that fouling of components in the control oil system had caused the governor's response to be too slow to control the turbine's initial acceleration. Subsequent turbine starts were successful because the governor's components had been sufficiently exercised and loosened to permit faster response.

On June 18, 1990, during fast start surveillance testing at the LaSalle County Nuclear Station, Unit 1, the reactor core isolation cooling (RCIC) turbine tripped on overspeed and the licensee declared the system inoperable. The licensee determined that contaminated oil had fouled the components of the governor, slowing the governor's response and causing the turbine to trip on overspeed.

In October 1990, the licensee at the Millstone Nuclear Power Station, Unit 3, declared the turbine-driven AFW pump inoperable when the turbine tripped repeatedly on overspeed during testing. The licensee noted that, before each test start, the turbine was rolling because of steam leaking past the steam admission valves. The licensee determined that the turbine rolling caused oil to be admitted into the governor's speed setting cylinder which resulted in the overspeed trips.

Discussion:

ANO-2 has one AFW pump powered by a motor and one powered by a steam turbine. Upon initiation of a start signal to the turbine-driven pump, a bypass valve around the normally closed isolation valve in the steam supply line to the turbine opens and the turbine accelerates to a minimum idle speed. Following a preset time delay, the isolation valve opens and the turbine governor valve positions to allow the turbine to accelerate to rated speed. The governor valve is positioned by an electronic governor type-R (EG-R) hydraulic actuator in conjunction with a remote servo valve. The EG-R actuator converts the electrical speed demand signal to a hydraulic signal which is then sent to the servo to adjust the governor valve's position. The hydraulic medium for the governor control system is filtered oil taken from the turbine lube oil system.

After the December 6, 1990, overspeed trip, the licensee for ANO-2 brought a field representative of the Woodward Governor Company onsite to help determine the cause of the recurring overspeed trips. Upon examination, the control oil was found to be contaminated with dirt and grit. A thick gelatinous coating of dirt and hardened oil was observed on some governor components including the EG-R actuator and remote servo. The three overspeed trips resulted from contaminated oil that slowed the response of the governor. To correct this condition, the licensee changed the turbine lube oil, replaced the filter, cleaned the remote servo and control tubing, and replaced the EG-R actuator. The licensee tuned the governor to ensure proper response and successfully tested the turbine. The licensee declared the pump operable and returned it to service.

The ANO preventive maintenance (PM) program provided for sampling the turbine lube oil each month and for changing the lube oil and filter every six months.

Maintenance records showed that the licensee had changed the lube oil and filter on September 2, 1990, approximately two months before the overspeed trip on November 13, 1990. However, the PM program did not provide for periodic inspections of the oil sump and other components of the governor control oil system. The vendor manual for the Terry Corporation turbine contained a note stating that oil used to fill the turbine lube oil system should be filtered through a 5-micron filter. The licensee had overlooked this note and had not performed this step when filling the system. Since the inline filter in the lube oil system is a 25-micron filter, the lube oil system contained a large quantity of particles of approximately 5 to 25 microns. This condition and the low flow rate of oil through the governor resulted in a heavy accumulation of impurities in the governor. Because the accumulation occurred over a period of years, the periodic oil sampling and changing of the oil and filter in the turbine lube oil system failed to control or detect the accumulation of particles inside the governor. The licensee revised the PM program to include periodic cleaning or replacement of the EG-R actuator and its associated remote servo valve. The licensee plans to clean the turbine lube oil system during the next refueling outage.

On June 18, 1990, the licensee at LaSalle County Nuclear Station, Unit 1, identified a similar problem. During fast start testing, the RCIC turbine tripped on overspeed. The licensee's investigation included the removal and inspection of the EG-R actuator. The licensee found sediment inside the actuator and on the actuator's components. The licensee tested the oil for particles between 5 and 250 microns and found that the amount of these particles greatly exceeded allowable limits. To prevent the problem from recurring, the licensee revised the plant procedure to require the oil to be filtered before filling the turbine lube oil system. Also, the licensee will flush the oil system and disassemble, inspect, and clean the EG-R actuator during each outage.

In October 1990, during testing of the turbine-driven AFW pump at Millstone Unit 3, the turbine tripped repeatedly on overspeed. The licensee noted that the turbine shaft was rotating before each of the test starts caused by steam leaking past the steam admission valve. The turbine rolling caused oil to be admitted into the governor's speed setting cylinder. The combination of the turbine's initial rolling and the position of the speed setting bushing was sufficient to cause the turbine to trip on overspeed during the turbine's initial acceleration. The licensee developed a maintenance program to eliminate the steam leaking past the admission valve and also to periodically check if the turbine is rolling.

In AEOD report C602, the staff identified several turbine overspeed events related to oil contamination. The events at ANO and LaSalle have revealed an additional mechanism by which contaminated oil can cause turbine-driven pump overspeed trips. These events demonstrate that turbine governor control oil systems are sensitive to the accumulation of impurities in the oil or on surfaces exposed to the oil medium. To compensate for this sensitivity, licensees may wish to periodically examine and clean these critical components in addition to the traditional practice of periodically changing the lube oil and filters.

In the AEOD report, the staff also noted that steam valve leakage and undrained condensate can cause overspeed trips. The staff listed three events of turbine overspeed caused by steam valve leakage. Those events occurred at the St. Lucie Plant, Unit 2, the Crystal River Plant, Unit 3 and the Virgil C. Summer Nuclear Station. The turbines at these three plants are equipped with Woodward PG-PL governors which are set to control turbine acceleration properly when the turbine starts from rest. These turbines tripped on overspeed because the turbines were rolling before being started which increased the oil pressure and caused oil to flow into the governors' speed setting cylinder. The oil pressure in the cylinder prevented the governor from responding fast enough to close the governor valve and control the initial turbine acceleration. This overspeed problem is not limited to the PG-PL type governor. Other types of Woodward governors that use a ramp bushing to control acceleration may also trip on overspeed. In addition, the increased oil pressure in the speed setting cylinder does not decrease immediately and must be released by locally exercising and resetting the speed setting knob. This characteristic may cause the turbine-driven pump to be unavailable for immediate starts or quick restarts.

At Crystal River, the licensee installed a modified governor with an automatic bleed feature to relieve oil pressure in the speed setting cylinder. This modification should prevent the turbine from tripping on overspeed as a result of the turbine rolling before the pump is started.

In the AEOD report, the staff identified nine turbine overspeed trip events that occurred as a result of undrained condensate in the turbine steam supply lines. Although steam lines are usually designed to separate and remove condensate, it is possible that during a cold start the condensate may not be separated or removed fast enough to prevent it from reaching the turbine. Because this condensate contains significantly less energy than an equivalent mass of steam, the turbine's initial acceleration is slower than expected. In response to the slower acceleration, the governor opens the governor valve further to allow more steam to enter. However, once the condensate clears, the governor cannot respond fast enough to prevent the turbine from tripping on overspeed.

The actual condition causing such an overspeed trip is often not determined because subsequent restarts are usually successful as the steam line has been heated and the condensate removed. To prevent similar trips, these plants increased the capacity of the condensate removal process or minimized the condensate formation by keeping the steam supply line in a hot and pressurized condition.

Previous Similar Occurrences:

The staff reviewed LERs received since the middle of 1985 and identified two turbine overspeed trips caused by undrained condensate. It is likely that other turbine overspeed trips have occurred but were not reported. The overspeed trips caused by undrained condensate occurred at San Onofre Nuclear Generating Station, Unit 2, in August 1990, and at the Crystal River Plant, Unit 3, in November 1986. The turbine overspeed trip at San Onofre occurred during testing. Initially, the licensee could not determine the cause of the

trip because subsequent restarts were successful. However, during a followup investigation, the licensee found that a procedural deficiency had resulted in an isolation valve for a steam trap remaining closed after a previous outage. The licensee modified the procedure to ensure that the valve was properly aligned and added a program to check the steam drain system periodically. At Crystal River, the AFW system actuated automatically. The turbine-driven AFW pump started as required but immediately tripped on overspeed. The motor-driven AFW pump started normally and supplied feedwater to the steam generators. The licensee later found that the warmup line for the turbine throttle valve had been isolated for unknown reasons and had allowed the steam supply line to cool. Condensate formed in the steam supply line and caused the turbine to trip on overspeed. The licensee revised procedures to ensure that the warmup line was not inadvertently isolated.

The NRC issued IN 86-14 and its supplement to alert addressees to the possibility that turbine-driven pumps could trip on overspeed and to summarize the results of AEOD report C602. However, the staff believes some licensees are not fully aware of the problem or may have inadequate programs to control the problem. AEOD is continuing to study the reliability of safety-related steam turbine-driven standby pumps to address the continuing repetitive failures of turbine assemblies. Further information will be issued to addressees if appropriate.

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 NRR project manager.

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Attachment:
List of Recently Issued NRC Information Notices

LIST OF RECENTLY ISSUED
NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
91-51	Inadequate Fuse Control Programs	08/20/91	All holders of OLs or CPs for nuclear power reactors.
91-50	A Review of Water Hammer Events After 1985	08/20/91	All holders of OLs or CPs for nuclear power reactors.
91-49	Enforcement of Safety Requirements for Radiographers	08/15/91	All Nuclear Regulatory Commission (NRC) licensees authorized to use sealed sources for industrial radiography.
91-48	False Certificates of Conformance Provided by Westinghouse Electric Supply Company for Refurbished Commercial-Grade Circuit Breakers	08/09/91	All holders of OLs or CPs for nuclear power reactors.
91-47	Failure of Thermo-Lag Fire Barrier Material to Pass Fire Endurance Test	08/06/91	All holders of OLs or CPs for nuclear power reactors.
89-56, Supp. 2	Questionable Certification of Material Supplied to the Defense Department by Nuclear Suppliers	07/19/91	All holders of OLs or CPs for nuclear power reactors.
91-46	Degradation of Emergency Diesel Generator Fuel Oil Delivery Systems	07/18/91	All holders of OLs or CPs for nuclear power reactors.
91-45	Possible Malfunction of Westinghouse ARD, BFD, and NBFD Relays, and A200 DC and DPC 250 Magnetic Contactors	07/05/91	All holders of OLs or CPs for nuclear power reactors.

OL = Operating License
CP = Construction Permit