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

December 2, 1994

NRC INFORMATION NOTICE 94-84: AIR ENTRAINMENT IN TERRY TURBINE LUBRICATING OIL SYSTEM

Addressees

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

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to potential problems caused by air entrainment in the lubricating oil system in turbines manufactured by the Steam Turbine, Motor, and Generator Division of the Dresser-Rand Company (formerly the Terry Steam Turbine Company). 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

Three nuclear power plants have recently experienced problems with the lube oil system on turbine-driven pumps manufactured by the Terry Steam Turbine Company (Terry Turbine).

Pilgrim Nuclear Power Station

On August 5, 1994, during postmaintenance testing of the reactor core isolation cooling (RCIC) turbine at the Pilgrim Nuclear Power Station (Pilgrim), maintenance personnel noted that the inboard (coupling end) bearing oil level was decreasing while the oil level in the outboard (governor end) bearing was increasing after the turbine had been running at rated speed for about 15 minutes. At that time, turbine speed fluctuated and an oil mist was observed spraying from the outboard bearing housing. The turbine was manually tripped, and an investigation into the change in oil levels was begun.

The investigation showed that the cause of the changes in oil level was air entrainment in the oil. A bubble of air had formed in the 1-inch drain line from the outboard bearing and had retarded the drainage of oil from the bearing back to the sump. With the drain path blocked, the oil level
increased as more oil was pumped to the outboard bearing. Since only a small amount of oil was draining back to the sump from the outboard bearing, the

major source of oil to the sump and the oil pump was the oil draining from the inboard bearing. The turbine vendor representative stated that the most likely cause of the air entrainment was the pumping action of the overspeed trip disk, which aerates the oil. Another possible source of air inleakage was the oil pump suction tubing and connections. The licensee replaced the pump suction piping and sealed susceptible joints to eliminate air inleakage. The licensee also replaced the oil with oil used before the refueling outage to determine if the new oil was foaming. The RCIC system was run after each change, and each time the same changes in oil level and the speed fluctuations occurred after 15 minutes. The licensee noted that the normal RCIC system surveillance test run time of 6 to 10 minutes at rated speed and flow is not long enough to identify this problem.

After discussions with the governor control system vendor (Woodward), and with concurrence from the turbine vendor, the licensee reduced the lube oil pump discharge pressure from 182-203 kilopascals (kPa) [12-15 pounds per square inch gauge (psig)] to 154-168 kPa [8-10 psig]. The lube oil pump, a Tuthill model# ORFD 1 with a rated flow of 6.62 liters per minute [1.75 gallons per minute (gpm)], is driven by the RCIC pump through a worm gear arrangement. The turbine was then run satisfactorily with no indication of anomalous lube oil performance.

Sequoyah Nuclear Plant, Unit 1

On November 6, 1994, the licensee for Sequoyah experienced a similar lube oil leak on the turbine-driven auxiliary feedwater (TDAFW) pump during a surveillance test run. Troubleshooting efforts, including ultrasonic testing, determined that air voids were forming in the outboard drain line, preventing adequate oil return from the outboard bearing housing, and resulting in oil level fluctuations between the two bearing housings.

Investigation determined that the air voiding phenomenon was time dependent, which raised questions about the adequacy of the duration of previous TDAFW pump test runs. Factors such as pump speed, oil system configuration, and oil system pressure, could affect when this phenomenon would occur. The licensee corrective actions included installation of an atmospheric vent at the top of the outboard bearing drain line and replacement of a portion of the 1-inch drain line with a 1.5-inch drain line (see Figure 1). An extended test run following the modifications verified that the problem was corrected.

Browns Ferry Nuclear Plant, Unit 2

On November 27, 1994, the licensee for Browns Ferry identified a similar problem with oil level perturbations on the RCIC turbine. The licensee made modifications similar to those at Sequoyah and the problem was corrected.

Discussion

The pressurized lubricating oil system on a Terry turbine is designed to provide oil to both the coupling end bearing and the governor end bearing. The oil drains from the bearings through 1-inch drain lines that terminate at different ends of a 3-inch diameter equalizing line that serves as a sump for the lube oil pump. The pump takes suction from the governor bearing end of the sump. The equalizing line slopes upward toward the outboard bearing housing, so that any entrapped air rises toward the drain line for that bearing, retarding drainage of oil back to the sump.

The problem begins when entrained air causes foaming of the oil that prevents proper drainage from the outboard bearing housing and its oil level begins to increase. When the level rises to the point where the overspeed trip disk is rotating in oil, more aeration and foaming occur, exacerbating the problem.

The turbine vendor was aware of this problem and had suggested modifications for other plants that had experienced similar problems. Other plants identified included Monticello Nuclear Plant, Salem Generating Station, and Duane Arnold Energy Center.

The turbine vendor has indicated that all of its turbines are typically tested at the factory for 4 hours before shipment. When some of the turbines exhibited problems similar to that at Pilgrim during the 4-hour factory test run, the vendor replaced the 1-inch drain line on the outboard bearing with a 1.5-inch line to alleviate the problem. Also, if the problem develops after shipment, it is usually discovered during startup testing and is corrected by installation of the 1.5-inch line. Some licensees with turbines that experienced the problem in the field have also installed vent lines at the bearing housings or the bearing housing drain lines to prevent air bubbles from building up in the drain line. The vendor noted that turbines with auxiliary oil pumps, which include all high pressure coolant injection (HPCI) systems in BWRs will not experience this problem. However, turbines with only the gear-driven oil pump, which includes both the RCIC turbines in boiling water reactors and auxiliary feedwater (AFW) and emergency feedwater (EFW) turbines in pressurized water reactors may be susceptible to the air entrainment phenomenon.

The principal demand for full flow from the turbine driven pumps in question occurs during the first 15 minutes of postulated events. In a BWR, if the RCIC system were used to maintain reactor vessel level during an event when the main feedwater system and main condenser were unavailable, the demand would be well below the design speed and flow. Likewise, the TDAFW pumps in many PWRs are rated at 150-200 percent of actual demand capacity. Generally, the TDAFW pumps are throttled back or secured during an event because of overcooling concerns. The frothing problem is less likely to occur at lower speeds.

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.

/s/'d by BKGrimes

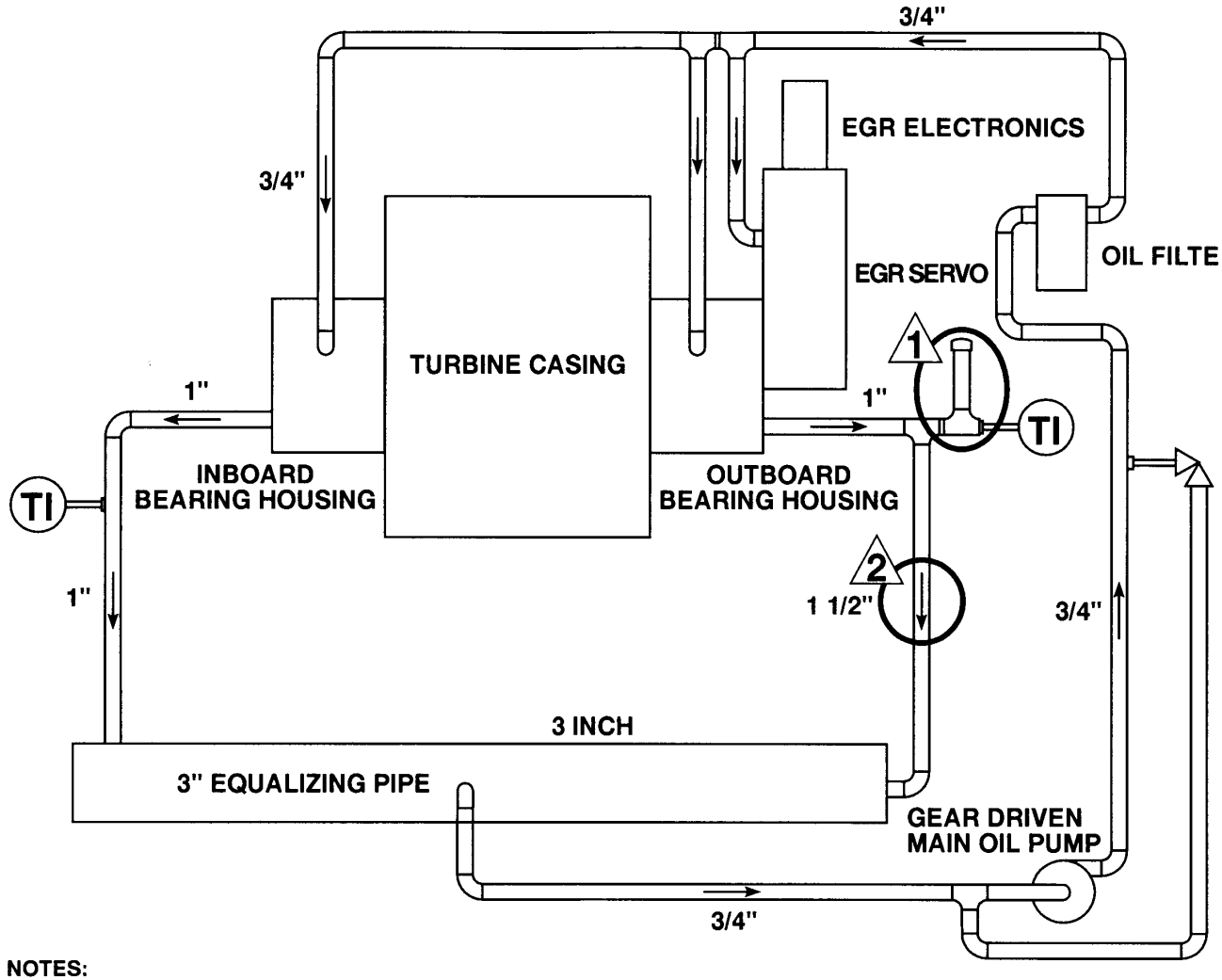
Brian K. Grimes, Director
Division of Project Support
Office of Nuclear Reactor Regulation

Technical contacts: John Boardman, AEOD
(301) 415-6354

David Skeen, NRR
(301) 504-1174

Scott Schaeffer, RII
(615) 842-8001

Attachments:
1. Figure 1, Modified Terry Turbine Oil Lubrication System at Sequoyah Nuclear Plant
2. List of Recently Issued NRC Information Notices



NOTES:

1. ADDITION OF ATMOSPHERIC VENT AT THE TOP OF THE OUTBOARD BEARING DRAIN LINE.
2. OUTBOARD BEARING HOUSING DRAIN LINE ENLARGED FROM 1" TO 1 1/2".

MODIFIED TERRY TURBINE OIL LUBRICATION SYSTEM AT SEQUOYAH NUCLEAR PLANT