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UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, DC 20555

March 10, 1986

IE INFORMATION NOTICE NO. 86-14: PWR AUXILIARY FEEDWATER PUMP TURBINE CONTROL PROBLEMS

Addressees:

All nuclear power reactor facilities holding an operating license (OL) or a construction permit (CP).

Purpose:

This information is provided to alert recipients of potential problems of overspeed trips of turbine-driven auxiliary feedwater (AFW) pumps which contribute to systems unavailability. Similar overspeed trips are employed on turbine-driven high pressure injection pumps and reactor core isolation cooling pumps.

It is expected that recipients will review the information in this notice for applicability to their facilities and consider actions, if appropriate, to preclude similar problems occurring at their facilities. However, suggestions contained in this information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

There have been four relatively recent events during which the turbine-driven AFW pumps tripped as a result of overspeed to a "lockout" condition that required manual reset at the turbine to return the component to an operable status. In two events, the cause was the presence of oil pressure in the turbine governor before receipt of an initiating signal. These events occurred at Turkey Point and Crystal River. In the other two events, the overspeed trip was attributed to condensate in the feedwater turbine steam lines. These events occurred at Davis-Besse and Palo Verde.

The events cited are examples of system malfunctions where individual components responded as designed. However, the system was unable to perform its intended function because overall system dynamic problems were not fully considered.

At Turkey Point all three AFW turbines responded properly when called on after a reactor trip. When later required to restart, two of the AFW turbines tripped to lockout on overspeed and the third turbine tripped (from a different device) on overspeed.

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At Crystal River, the AFW turbine tripped on overspeed during performance of a routine operability test.

At Davis-Besse one of two turbine-driven main feedwater pumps tripped while the unit was operating at 90 percent power. Steam to the second main feedwater pump turbine was lost when the main steam isolation valves spuriously closed. After the resultant reactor trip, the turbine-driven AFW pumps started on demand, but tripped on overspeed. Various other problems developed, which are discussed in IE Information Notice 85-50, IE Bulletin 85-03, and in greater detail in NUREG-1154.

At Palo Verde, the AFW turbine tripped on overspeed during a startup test.

In each of these instances an operator was required to go to the turbines and manually reset the equipment for restart. These events were similar in consequences, but had different underlying causes.

Discussion:

Historically, PWRs have been required to have redundant AFW systems to remove residual reactor decay heat after scram. Normally, at least one of the systems has been powered by other than an electric motor, to address the contingency of loss of all ac power. Nearly all current PWR licensees have a small steam turbine drive, most of which are Terry Corporation single-stage noncondensing turbines with Woodward governors. Woodward governors used with Terry turbines do not have an internal overspeed trip device. The turbine has a mechanical overspeed trip that will trip the "trip-and-throttle" valve at 150 percent of nominal speed. Terry Corporation recommends visual post-trip examination of the equipment, following mechanical overspeed trip and has the trip linkage arranged to require local manual reset at the turbine. Many turbines are equipped with additional speed sensing devices that can be used to trip the turbine at some lower overspeed, e.g., 125 percent.

Woodward mechanical-hydraulic governors sense the speed of the turbine through gearing that rotates the mechanical fly weights and provides power to supply hydraulic oil to the governor. The governor acceleration control feature is set to function properly on a start signal when the turbine starts from a dead stop with no initial oil pressure in the governor control system.

Control oil pressure does not decay immediately when a governor is shut down. Depending on internal clearances, it may take as long as 30 minutes to fully decay. Some facilities utilize power-operated auxiliary devices to provide for remote control of governor speed setting and to "dump" residual oil from the hydraulic system. However, the most commonly used device seems to be a speed setting knob that must be adjusted manually at the governor. This requires that the governor speed be turned down to a minimum to dump the excess oil and then reset to the desired speed. This action introduces two possibilities for human error: the operator may inadvertently not fully dump the hydraulic system or may not correctly reset the speed control.

Details of Recent Events:

At Turkey Point all three pumps started properly on the first demand. During recovery from the event, the pumps were no longer needed and were shut down. The turbine governors were reset per procedure, but as discussed above, perhaps not properly reset. During the continuing course of the plant transient, the AFW systems received another auto-start signal. Two of the turbines experienced overspeed and tripped to lockout. The third turbine-driven pump had experienced problems with a feedwater discharge flow control valve, and the steam supply valves had been placed in an unusual configuration to facilitate troubleshooting on the water flow control valve. The turbine started automatically, but somewhat more slowly than normal. It experienced overspeed, as did the others, but in this case the acceleration rate was slow enough that the electric overspeed device activated and tripped the "trip-and-throttle" valve. Immediately on closure the trip signal cleared and a reset signal was generated. The turbine governor had not been reset, and as the valve opened, the turbine restarted, went to overspeed, was intercepted and shut down by the electric device, and continued this cycling until manually secured. The initial corrective action was to clarify the governor reset procedure and to retrain the operators. Since then the licensee has engaged in a major system design review and upgrade.

At Crystal River, the single turbine drive had apparently been properly shut down, but during the interval between test operations, the steam supply valve had developed a slight leak, enough so that the turbine was "idling" at about 160 rpm, a speed sufficient to activate the governor hydraulic system. When the start signal was initiated, the turbine accelerated rapidly and tripped to lockout on overspeed. The licensee corrective action was to overhaul the steam supply valve so that it no longer leaked.

At Davis-Besse, the licensee reports that the turbine overspeed events were caused by the presence of undrained condensation in the steam supply lines. The particular lines being used at the time of the overspeed events were used only following certain accident sequences and were not normally pressurized and heated. These lines have long horizontal runs in which large quantities of condensate could collect. When the AFW start signal caused the steam supply valves to open, much of the steam initially introduced was condensed by the cold pipe and then swept into the turbines. This water, containing significantly less energy than an equivalent mass of steam, caused the turbines to accelerate slowly and the governors to open the control valves farther than normal. When the condensate cleared the turbines and was replaced by steam, the governors could not react rapidly enough to prevent the turbines from overspeeding and locking out. The auxiliary feedwater system had not been tested in this configuration before the overspeed events. The initial corrective action during the transient was to control the AFW turbines by local manual control. Currently the system is undergoing extensive design review and revision.

At Palo Verde, the licensee reports that, like Davis-Besse, the overspeed trip also occurred because of condensation in the steam supply line. The circumstances differ, however, in detail. As at Davis-Besse, the branch connection from the main steam supply lines was fairly long, but was intended to be

pressurized to the turbine stop valve whenever steam was available. Traps and drain connections were provided to ensure that any condensation was continuously removed. However, these devices had not been verified to be functional and properly adjusted, and in fact, significant quantities of condensate were injected into the AFW turbine on startup. Corrective action was to verify that installed condensate removal devices functioned according to design, and that procedures required periodic verification of operability.

All of the above-described events resulted in unavailability of the AFW system requiring operator action to restore system operability. The underlying causes include inappropriate system design, poor operating procedures, and inadequate maintenance.

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

Edward L. Jordan, Director
Division of Emergency Preparedness
and Engineering Response
Office of Inspection and Enforcement

Technical Contact: James B. Henderson, IE
(301) 492-9654

Attachment: List of Recently Issued IE Information Notices

LIST OF RECENTLY ISSUED IE INFORMATION NOTICES

Information Notice No.	Subject	Date of Issue	Issued to
86-13	Standby Liquid Control System Squib Valves Failure To Fire	2/21/86	All BWR facilities holding an OL or CP
86-12	Target Rock Two-Stage SRV Setpoint Drift	2/25/86	All power reactor facilities holding an OL or CP
86-11	Inadequate Service Water Protection Against Core Melt Frequency	2/25/86	All power reactor facilities holding an OL or CP
84-69 Sup. 1	Operation Of Emergency Diesel Generators	2/24/86	All power reactor facilities holding an OL or CP
86-10	Safety Parameter Display System Malfunctions	2/13/86	All power reactor facilities holding an OL or CP
86-09	Failure Of Check And Stop Check Valves Subjected To Low Flow Conditions	2/3/86	All power reactor facilities holding an OL or CP
86-08	Licensee Event Report (LER) Format Modification	2/3/86	All power reactor facilities holding an OL or CP
86-07	Lack Of Detailed Instruction And Inadequate Observance Of Precautions During Maintenance And Testing Of Diesel Generator Woodward Governors	2/3/86	All power reactor facilities holding an OL or CP
86-06	Failure Of Lifting Rig Attachment While Lifting The Upper Guide Structure At St. Lucie Unit 1	2/3/86	All power reactor facilities holding an OL or CP

OL = Operating License
CP = Construction Permit