

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, D.C. 20555

September 19, 1985

IE INFORMATION NOTICE NO. 85-76: RECENT WATER HAMMER EVENTS

Addressees:

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

Purpose:

This notice is to inform recipients of recent water hammer events in steam supply lines to auxiliary feedwater (AFW) pump turbines, a steam exhaust line from a high pressure coolant injection (HPCI) pump turbine, and discharge lines from feedwater pumps (involving pump start logic). It is expected that recipients will review the information for applicability to their facilities and consider actions, if appropriate, to preclude a similar problem 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:

In the past, the NRC has studied water hammer events in its Unresolved Safety Issue (USI) A-1. Most of these events involved either the feedwater or steam generator systems in pressurized water reactors (PWRs). In publishing its technical findings relevant to this issue (Reference 1), the NRC realized that total elimination of water hammer is not feasible, because of the possible coexistence of steam, water, and voids in various nuclear plant systems. The frequency of events forming the subject of USI A-1 peaked in the mid-70's but then decreased as corrective equipment designs and procedures came into use. Recently, additional events have been reported indicating an increased frequency.

AFW Pump Turbine Steam Supply Lines

Water hammer events have been previously reported in the steam supply lines to HPCI and reactor core isolation cooling (RCIC) turbines in boiling water reactors (BWRs), as discussed in Reference 1, but have not been previously reported with any frequency in steam supply lines to AFW (or equivalent system) turbines in PWRs.

On May 8, 1985, at Waterford 3, an event occurred during an AFW surveillance test that damaged 7 struts and 1 snubber supporting the steam supply line to the turbine driven pump. The system passed the surveillance test satisfactorily. These steam supply lines at Waterford employ heat tracing circuits to keep the empty portions of pipe above 280°F to prevent water collection. The licensee observed that two heat tracing circuits on a long run of empty pipe had not been operating properly and identified two low points as possible sources of water slugs.

While not all of the licensee's investigations have been completed, the most likely explanation of the event is water hammer from a steam driven water slug produced by condensed weepage past the closed isolation valve into the normally empty pipe. The licensee's corrective actions include assuring the heat tracing circuitry is keeping the pipe above 280°F and adding drains to the low points.

Similar events have been reported at Diablo Canyon 1, on June 6, 1985, and at San Onofre 3, on April 16, 1985. In both these events, damage was restricted to pipe support snubbers and both systems passed the surveillance tests satisfactorily. At Diablo Canyon, steam traps on the supply line had been inadvertently left isolated. At San Onofre, the cause could not be established, but the licensee has decided to replace the existing steam traps with orifices to reduce the possibility of collecting condensation in the pipe.

Before March 21, 1985, at Davis-Besse, damage was found to pipe hangar supports on long, unheated, approximately horizontal sections of the crossover supply lines to the turbine driven pumps. This damage is likely due to acceleration of water slugs formed from condensation of steam in these lines. While not definitely concluding so, the licensee suspects that the formation might also have contributed to overspeed trips of both turbines on June 9, 1985, and other irregularities in turbine speed characteristics before that date. (Information Notice No. 85-50 provides further information about the Davis-Besse event of June 9, 1985.)

HPCI Pump Turbine Steam Exhaust Line

Water hammer events in the steam exhaust lines of HPCI and RCIC turbines in BWRs have been discussed in References 1 and 2. The following events, while similar in some respects, introduce new information relating the events to the operation of the turbine.

On April 2, 1985, at Pilgrim, the licensee found a failed inner rupture disk on the HPCI turbine exhaust line and a damaged snubber near the torus penetration of the line. Believing that a water hammer had occurred from trapped condensate because the exhaust line had not been purged with nitrogen before a prompt manual restart after a turbine trip, the licensee decided to purge the exhaust line for a longer time after system operation and to inspect the line supports following system operation.

On May 18, 1985, the Pilgrim licensee found two damaged snubbers on the HPCI steam exhaust line after another surveillance test. The licensee believes that the snubber damage may have occurred when the HPCI turbine tripped, slowed, and automatically restarted after only a few seconds during the test. The damage occurred on the exhaust line near the torus penetration downstream of the vacuum breaker and stop check valve.

To lessen the severity of transients caused by quick starts of the turbine, the licensee revised HPCI procedures to manually control the speed on starting and installed a bypass line around the governor's actuator assembly to increase hydraulic pressure downstream of the actuator's internal pump. On testing, the licensee found the initial spike in turbine speed to be lessened considerably. These changes were designed to decrease the likelihood of overspeed tripping on starting.

The water hammers likely were caused by water being siphoned into the exhaust line from the suppression pool as steam in the exhaust line condensed. The operation of the drain and vacuum breaker subsystems on the line may not have been adequate for the short operating cycles experienced. For example, the vacuum breaker is only of 1-inch size for a 20-inch exhaust line. The licensee now is considering installing a bigger vacuum breaker on the line near the torus penetration. This type of problem, which could be expected to occur in an actual demand under accident conditions, might not be noticed on surveillance testing if fast-start testing were not employed.

Logic Problems With Main Feedwater Pump Restart

On August 21, 1984, the licensee at McGuire 1 experienced a loss of offsite power, which with the manual closing of the main steam isolation valves required by the event resulted in a loss of all condensate and feedwater pumps. The loss of power also caused the feedwater pump recirculation valves to the condenser to fail open as designed. This partially drained the feed system. When power was restored and the feed pumps manually restarted, water hammer occurred.

Inspection revealed that the water hammer caused only minor damage to condensate booster pump discharge pressure gauges. The licensee is modifying procedures to minimize the possibility of water hammer on pump restart following a loss of offsite power. This is an example of a system being designed to drain on loss of power, creating the conditions for subsequent water hammer. Similar conditions also have been reported for the auxiliary saltwater systems at Diablo Canyon Units 1 and 2.

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 this office.


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

Technical Contact: V. Hodge, IE
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Attachments:

1. References
2. List of Recently Issued IE Information Notices

References

1. "Evaluation of Water Hammer Occurrence in Nuclear Power Plants," NUREG-0927, Revision 1, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, March 1984.
2. "Water Hammer in Boiling Water Reactor High Pressure Coolant Injection Systems," Engineering Evaluation Report No. AEOD/E402, Office of Analytical Evaluation of Operational Data, U.S. Nuclear Regulatory Commission, January 10, 1984.

LIST OF RECENTLY ISSUED
 IE INFORMATION NOTICES

| Information Notice No. | Subject | Date of Issue | Issued to |
|------------------------|-----------------------------------------------------------------------------------------------------------|---------------|--------------------------------------------------|
| 85-75 | Improperly Installed Instrumentation, Inadequate Quality Control And Inadequate Post-modification Testing | 8/30/85 | All power reactor facilities holding an OL or CP |
| 85-74 | Station Battery Problems | 8/29/85 | All power reactor facilities holding an OL or CP |
| 84-70 Sup. 1 | Reliance On Water Level Instrumentation With A Common Reference Leg | 8/26/85 | All power reactor facilities holding an OL or CP |
| 85-73 | Emergency Diesel Generator Control Circuit Logic Design Error | 8/23/85 | All power reactor facilities holding an OL or CP |
| 85-72 | Uncontrolled Leakage Of Reactor Coolant Outside Containment | 8/22/85 | All power reactor facilities holding an OL or CP |
| 85-71 | Containment Integrated Leak Rate Tests | 8/22/85 | All power reactor facilities holding an OL or CP |
| 85-70 | Teletherapy Unit Full Calibration And Qualified Expert Requirements (10 CFR 35.23 And 10 CFR 35.24) | 8/15/85 | All material licensees |
| 85-69 | Recent Felony Conviction For Cheating On Reactor Operator Requalification Tests | 8/15/85 | All power reactor facilities holding an OL or CP |
| 85-68 | Diesel Generator Failure At Calvert Cliffs Nuclear Station Unit 1 | 8/14/85 | All power reactor facilities holding an OL or CP |

OL = Operating License
 CP = Construction Permit