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

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NRC INFORMATION NOTICE 2005-30: SAFE SHUTDOWN POTENTIALLY CHALLENGED BY UNANALYZED INTERNAL FLOODING EVENTS AND INADEQUATE DESIGN

ADDRESSEES

All holders of operating licenses for nuclear power reactors, 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 alert addressees to the importance of establishing and maintaining the plant flooding analysis and design, consistent with NRC requirements and principles of effective risk management, to ensure that internal flooding risk is effectively managed.

It is expected that recipients will review the information for applicability to their facilities and consider corrective actions, as appropriate. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

At the Kewaunee Power Station (KPS), multiple trains of safety-related systems necessary for safe-shutdown (e.g., auxiliary feedwater, emergency diesel generators, and electrical distribution switchgear) are located at the same elevation and immediately adjacent to the turbine building (TB) basement. Water from a TB flood could have flowed into these spaces through non-watertight doors and through the floor drain system, which consisted of an open pipe connecting the spaces to the turbine building sump. Several non-safety related systems are located within the turbine building that have the potential to release large volumes of water in the event of a pressure boundary failure. These systems include the circulating water, condensate storage, and fire protection systems. In the case of the fire protection system, a large volume of water could be released from system actuation. Although infrequent, U.S. nuclear power plant operating experience includes internal flooding events initiated by circulating water expansion joint failure and fire protection system pressure boundary failure.

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DISCUSSION

The design basis for KPS requires that safety-related systems, structures, and components (SSCs) be protected against damage from a pipe or tank rupture that releases enough water or steam to impair the safety function. In a letter to the NRC, dated October 31, 1972, the licensee previously reported that the consequences of failure of non-safety related systems could adversely affect the performance of engineered-safety systems. However, based on safety equipment redundancy and design arrangement, and on an assessment that appropriate control room operator action could effectively mitigate such events, the licensee had determined that the functional purpose of the safety equipment would not be jeopardized.

During performance of baseline inspection procedure 71111.06, Flood Protection Measures, NRC inspectors at KPS identified a potential internal flooding vulnerability. Following discussions with the inspectors and NRC staff, the licensee reported, in Event Notification 41496, that the KPS design might not mitigate the consequences of piping system failures and, in Licensee Event Report (LER) 2005-004 (ML051440302), that safe shutdown was potentially challenged by unanalyzed flooding events and inadequate design. Additionally, in the LER, the licensee reported that a complete internal plant flooding analysis was not developed during or subsequent to the plant's original design.

The potential for flooding to affect safety-related systems at KPS was demonstrated in 2003 when a minor turbine building flooding event caused less than an inch of water to collect at low points in some safety-related equipment rooms.

Corrective actions have been implemented or are in progress to ensure safety-related equipment will be adequately protected against postulated failures of non-safety related piping systems, including high energy line breaks, random pipe failures, and seismically induced pipe failures. These corrective actions include:

1. Compilation of design and licensing bases for internal flooding to support current and future flooding design

2. Seismic qualification of selected piping and components

3. Design modifications to protect Class I plant SSCs as defined in the KPS Updated Safety Analysis Report (USAR), including:

    a. installation of check valves in selected floor drains
    b. auxiliary feedwater pump lube oil cooler and drain flow path revisions
    c. installation of a circulating water pump trip on high TB basement water level
    d. flood barriers at doors to safety-related equipment rooms (safeguards alley)
    e. enhanced supports for auxiliary feedwater pump steam supply piping

4. The following interim protective actions were implemented pending completion of appropriate measures to ensure protection of Class I plant SSCs:

   a. The plant operating mode was restricted to refueling or cold shutdown.

   b. The maximum combined inventory of the condensate storage tanks and the reactor makeup tanks was restricted.

   c. Restrictions were placed on operation of the circulating water and condensate systems.

GENERIC IMPLICATIONS

Numerous flood-related vulnerabilities and events have been identified at nuclear power facilities both domestically and internationally. Flooding due to internal causes has been shown to be a significant contributor to risk at some facilities. It has the potential to make multiple trains of equipment and support equipment inoperable, significantly increasing plant risk. Flooding also has the significant consequence of preventing or limiting operator mitigation and recovery actions. A review of domestic and international operating experience revealed hundreds of flood-related events and findings, several of which were very similar to the event at KPS.

To address the generic implications of flooding, NRC inspectors semiannually select one or two plant areas and inspect internal flood protection features for risk-significant SSCs in accordance with Inspection Procedure Attachment 71111.06 "Flood Protection Measures." A review of findings documented under this inspection procedure from January 2000 through March 2005 turned up 39 findings (28 non-cited violations, 2 severity level IV violations, 8 GREEN findings, and 1 WHITE finding).

NRC generic communications that have addressed flood protection issues:

1. Circular CR 78-06 — Potential Common Mode Flooding of ECCS Equipment Rooms at BWR Facilities
2. IN 83-44 — Potential Damage to Redundant Safety Equipment as a Result of Backflow Through the Equipment and Floor Drain System
3. IN 83-44 S1 — Supplement 1: Potential Damage to Redundant Safety Equipment as a Result of Backflow Through the Equipment and Floor Drain System
4. IN 87-49 — Deficiencies in Outside Containment Flooding Protection

5. IN 92-69 Water Leakage from Yard Area Through Conduits into Buildings

6. IN 94-27 Facility Operating Concerns Resulting from Local Area Flooding

7. IN 98-31 Fire Protection System Design Deficiencies and Common-mode Flooding of Emergency Core Cooling System Rooms at Washington Nuclear Project Unit 2

8. IN 2005-11 Internal Flooding/spray-down of Safety-related Equipment Due to Unsealed Equipment Hatch Floor Plugs And/or Blocked Floor Drains

Other NRC References Addressing Flooding-Related Issues:

1. NUREG-0933 ISSUE 77 Flooding of Safety Equipment Compartments by Backflow Through Floor Drains (Rev. 1)

2. NUREG-0933 ITEM A-17 System Interactions in Nuclear Power Plants (Rev. 2)

CONCLUSION

The physical arrangement of safety-related systems essential to achieve safe-shutdown at KPS made these systems vulnerable to flooding originating from failures of non-safety related systems located in the turbine building. An NRC-identified condition at KPS revealed a less-than-effective application of operating experience to address safety-significant flooding-design vulnerabilities. This was based, in part, on the licensee's misunderstanding of the KPS licensing basis for the plant flooding analysis and design and on an erroneous assumption regarding the ability of control room operators to mitigate certain flooding events.

Consequently, the ability to achieve safe-shutdown for credible internal flooding events was not reasonably assured. The licensee and NRC found that the KPS USAR and other plant-specific NRC correspondence provided sufficiently clear guidance on the requirements to protect safety-related equipment from the effects of internal flooding. No safety-related equipment at KPS was flooded, but correcting the deficiencies of internal flooding design took a large part of an outage of approximately four months.

CONTACT

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

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Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.