UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

September 21, 2006

NRC INFORMATION NOTICE 2006-21: OPERATING EXPERIENCE REGARDING ENTRAINMENT OF AIR INTO EMERGENCY CORE COOLING AND CONTAINMENT SPRAY SYSTEMS

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 inform addressees of operating experience regarding possible entrainment of air into emergency core cooling systems (ECCS) and containment spray systems (CSS), potentially affecting the operability of these systems. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Several events have occurred at nuclear power facilities involving possible entrainment of air into ECCS and CSS piping. Air entrained in ECCS and CSS pump suction supply piping can impact the capability of the ECCS and CSS pumps to perform their specified safety functions. Three of these events are discussed below:

Palo Verde Nuclear Generating Station

During an NRC inspection at the Palo Verde Nuclear Generating Station, Units 1, 2, and 3 in the fall of 2005, a problem was discovered related to potential air entrainment into the ECCS and CSS suction header from the refueling water tank (RWT). (See NRC Inspection Report 05000528; 529; 530/2005012, Agencywide Documents Access and Management System (ADAMS) Accession No. ML060300193.) Specifically, the water level in the RWT could fall below the level of the suction supply line and associated vortex breaker following the transfer from the RWT to the containment sump after an accident. As a result, air could enter the ECCS and CSS piping system under accident conditions. This issue was determined to be applicable to both trains of all three units.

Following a loss-of-coolant accident (LOCA), the ECCS and CSS take suction from the RWT, until a recirculation actuation signal (RAS) occurs and the suction supply is aligned to the containment sump. The Palo Verde design does not include automatic closure of the RWT isolation valves with a RAS. This design relies on sufficient fluid pressure to backseat a check valve in the RWT supply line to stop the flow of water from the RWT.

Containment pressure analyses at Palo Verde were based on an assumed RWT temperature of 120EF. This is the maximum assumed RWT temperature allowed by technical specifications, and would be a conservative assumption for containment response calculations evaluating high pressures. However, this assumption is nonconservative for determining the minimum containment pressure under accident conditions.

Based on a calculation of the minimum containment pressure using the appropriate lowest expected RWT temperature, the containment pressure was calculated to be below that necessary to prevent air entrainment in the RWT supply. As a result, on October 11, 2005, the licensee determined that both trains of ECCS and CSS at all three units were outside their design bases and were declared inoperable. Operators at Units 2 and 3 entered limiting condition of operation (LCO) 3.0.3, "Unanalyzed Condition," and performed orderly shutdowns to Mode 5. Unit 1 was already shutdown at this time for scheduled refueling outage activities. Units 2 and 3 were later restarted following additional evaluations and other actions.

Waterford Steam Electric Station, Unit 3

During an NRC inspection at the Waterford Steam Electric Station, Unit 3 in the fall of 2004, a problem was discovered related to potential air entrainment into the ECCS and CSS pumps. (See NRC Inspection Reports 05000382/2004005 and 05000382/2006009; ADAMS Accession Nos. ML050390177 and ML062420513.) Specifically, the licensee made adjustments to the outside containment isolation valve in the line leading from the containment sump but failed to identify if the adjustments affected the leak tightness of the valve seat. During leak testing in September 2004, the licensee identified that the valve leaked excessively. The excessive leakage created a condition that could potentially result in premature closure of the reactor water storage pool (RWSP) downstream check valve, resulting in the loss of suction supply to a train of the ECCS and CSS pumps following a medium or large break LOCA. Even without sufficient pressure to close the RWSP downstream check valve, significant amounts of containment air leakage through the outside containment isolation valve could result in a large void content of the fluid entering the ECCS and CSS pumps, which could lead to failure of the pumps.

Clinton Power Station

During an NRC inspection at the Clinton Power Station in 2005 and part of 2006, a problem was discovered related to potential air entrainment into the high pressure core spray (HPCS) and reactor core isolation cooling (RCIC) suction supply lines from the RCIC water storage tank. (See NRC Inspection Report 05000461/2005002, ADAMS Accession No. ML060670370.) Specifically, the licensee did not select an appropriate method for calculating the onset of

vortexing at the intake of the HPCS and RCIC pumps' suction lines from the RCIC water storage tank. The licensee's calculation did not appropriately determine the minimum height of water above the HPCS and RCIC intake lines to preclude vortex formation. There were nonconservative assumptions made within the calculation which did not account for the likely presence of a fluid swirl at the intake, instead of a uniform flow field, and the change in the tank fluid level during stroking of suction valves during realignment of pump suction sources.

DISCUSSION

The above described events highlight the importance of proper engineering analysis in ensuring that entrained air will not enter suction supply lines and impair the ability of the ECCS and CSS pumps to perform their specified safety functions. These events emphasize the importance of adequately understanding how plant ECCS and CSS may be affected by plant changes and the importance of a critical review of analysis assumptions and margins. These three events involved different ways in which air could become entrained into the ECCS and CSS pumps, but all three had the same effect of potentially causing failure of the ECCS and CSS. The conditions which could have allowed air to be entrained had not been revealed by routine surveillance testing of pumping capability because it is not always practicable for the surveillance test to replicate the accident conditions that could cause air entrainment.

Air entrained by more than a few percent by volume may degrade or cause failure of centrifugal type pumps. A degraded pump which successfully expels small amounts of entrained air (or other gases), may become air (or gas) bound to such a degree that it will not restart after being stopped due to the coalescing of air into the pump casing. Additionally, voids in the pumped fluid can cause excessive vibration and wear of important internal parts.

Relevant Generic Communications

The following previous generic communications are relevant to the issue of air (or other gas) entrainment and its effects on ECCS and CSS performance:

NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors"

NRC Information Notice 2002-18, "Effect of Adding Gas Into Water Storage Tanks on the Net Positive Suction Head for Pumps"

NRC Information Notice 1998-40, "Design Deficiencies Can Lead to Reduced ECCS Pump Net Positive Suction Head During Design-Basis Accidents"

NRC Information Notice 1997-38, "Level-Sensing System Initiates Common-Mode Failure of High-Pressure-Injection Pumps"

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

CONTACT

This information notice requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below.

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ADAMS Accession Number: ML062570468

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