UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

September 19, 2007

NRC INFORMATION NOTICE 2007-28: POTENTIAL COMMON CAUSE VULNERABILITIES IN ESSENTIAL SERVICE WATER SYSTEMS DUE TO INADEQUATE CHEMISTRY CONTROLS

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 the importance of maintaining essential service water (ESW) systems in a manner that precludes the development of potential common cause failure vulnerabilities due to inadequate water chemistry controls. 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 IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

On May 17, 2006, the licensee at the Palo Verde Nuclear Generating Station (Palo Verde) noted elevated temperatures in the intake air for emergency diesel generator (EDG) 2B while the engine was running for a surveillance test. The engine intake air is compressed and heated by the turbocharger and is then cooled by two parallel intercoolers before entering the engine. The elevated temperatures were noted at the outlet of the intercoolers, which was indicative of inadequate cooling in the intercoolers.

The licensee inspected the EDG 2B intercoolers and found fouling/scaling on the cooling water (spray pond system) side with a white lotion-like substance. In addition to providing the cooling water to all the EDG coolers (two intercoolers, a jacket water cooler, and a lube oil cooler), the emergency spray pond system provides cooling to the essential cooling water (EW) system heat exchanger.

The Unit 2 EW heat exchangers were also taken out of service for inspection and tube cleaning. Similarly to the EDG intercoolers, they were found to have fouling/scaling that was reducing the heat transfer capabilities of the heat exchanger tubes.

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The licensee determined that the failure to properly maintain water chemistry in the Palo Verde cooling water spray ponds led to extensive fouling/scaling of the interior surfaces of heat exchanger tubes. The degraded heat transfer capabilities in the EDG coolers and the EW heat exchangers occurred in all trains in all units. The degree of degradation varied among the units. The EDG intercoolers and the EW heat exchangers were observed to have the most fouling/scaling; the jacket water and lube oil coolers fouling/scaling was minor and had no impact on operability. The difference in the amount of fouling/scaling was due to the fact that the heat exchanger tube skin temperatures were the highest for the EDG intercoolers followed by the EW heat exchangers. As the heat exchanger tube skin temperature increases, the rate of scaling increases.

Samples of the heat exchanger deposits at Palo Verde were analyzed and determined to be an amorphous mix of a number of substances. The major constituents were determined to be zinc, phosphorous, and calcium. The insulating film on the heat exchanger tubes included a zinc-hydroxide film, scale (calcium phosphate or calcium carbonate) and precipitant (calcium-zinc-phosphate). (Calcium is the major constituent of scale, which is contained in the makeup water source, unless the plant uses deionized or pure water. Calcium carbonate and calcium phosphate are common scale constituents. The zinc and phosphorous were from the scale/corrosion inhibitor that normally plates out on the surface in very small amounts).

The licensee's root cause assessment concluded that improper chemical control resulted in an insulating precipitant on the spray pond side of the heat exchanger surfaces. The improper chemistry control was a result of not enough dispersant, high pH, and improperly blowing down (feed and bleed) of the spray pond. The licensee personnel thought the spray pond had enough dispersant based on sample analysis; however, most dispersants blend a tracer chemical such as molybdenum (very minimal degradation with time) which provides an equivalent dispersant concentration for a fully active dispersant. Dispersants on average will last only 3 - 5 days when added to a cooling water system, and if stressed by temperature or other environmental conditions, will degrade more rapidly. Another important factor was that licensee personnel were not aware of the need to blowdown the system. As the water evaporated, all the incoming non-volatile contaminates, such as calcium, magnesium, and phosphorus, remained in the spray pond, thereby, concentrating and causing the system to become more prone to scale formation.

The licensee's chemistry personnel implementing the spray pond chemistry control program did not fully understand how the chemicals being added to the spray pond interacted with each other. As a result, the licensee implemented a series of inappropriate changes to the chemistry limits that negatively impacted solubility of critical materials without a clear assessment or understanding of the potential impacts of the changes.

Chemistry personnel did not adequately monitor the effectiveness of the anti-fouling portion of the essential spray pond chemistry regime. As a result, chemical precipitation occurred throughout the system. Accumulation of chemicals, impurities, and sediment in the spray ponds hindered chemistry control measures, affected thermal capacity and interfered with the station's ability to assess structural integrity.

The NRC dispatched a special inspection team to review the details surrounding the event. This issue is discussed in more detail in "Palo Verde Nuclear Generating Station, Units 1, 2, and 3 - NRC Special Inspection Report 05000528/2006011; 05000529/2006011; 05000530/2006011," dated September 28, 2006, Agencywide Documents Access and Management System (ADAMS) Accession Number ML062710607. NRC letter "Final Significance Determination," dated December 22, 2006, ADAMS Accession No. ML063600175, determined that a non-cited violation of technical specifications occurred because train B of the essential cooling water system in Unit 2 was not capable of performing its safety function and that the degraded performance was due to fouling caused by improper chemical addition in the associated spray pond.

BACKGROUND

The ESW system (or its equivalent) for U.S. commercial reactor plants is the assured, safety-related means of transferring decay heat from the reactor coolant system to the ultimate heat sink. The ESW system is also relied upon for other critical safety functions, such as (1) providing cooling water for most of the essential, safety-related equipment used for mitigating plant accident and transient conditions, (2) reactor coolant pump seal cooling, (3) spent fuel pool cooling, and (4) dissipating sensible and reactor decay heat during shutdown conditions.

ESW systems for U.S. nuclear power plants are generally unique from one plant to another. However, the ESW systems typically include a water source (such as a pond or cooling tower basin) where chemicals are added to inhibit internal corrosion of the piping, scale formation, algae/biological growth, and maintain pH within desired ranges, etc. Scale formation increases with increased heat exchanger skin temperature, reduced water velocity, higher pH, and a "dirty" water source (e.g., higher concentrations of chemicals such as calcium and magnesium).

Plant-specific probabilistic risk assessments have shown that the loss of the ESW system may be a significant contributor to the potential for a core damage accident.

Related Generic Communications

NRC Generic Letter (GL) 89-13, "Service Water System Problems Affecting Safety-Related Equipment," dated July 18, 1989, requested specific licensee actions to resolve service water (SW) system problems. In particular, this GL recommended that licensees ensure (by a routine inspection and maintenance program for open-cycle SW system piping and components) that corrosion, erosion protective coating failure, silting, and biofouling cannot degrade the performance of safety-related systems supplied by SW.

NRC IN 2006-17, "Recent Operating Experience Of Service Water Systems Due To External Conditions," dated July 31, 2006, alerted licensees to blockages in SW systems due to external conditions such as silt, sand, grass, frazil ice, and fish.

NRC IN 2007-06, "Potential Common Cause Vulnerabilities in Essential Service Water Systems," dated February 9, 2007, alerted licensees to events where corrosion of SW piping

and pitting due to microbiological-induced corrosion affected the structural integrity of the SW system.

DISCUSSION

The above Palo Verde event illustrates the importance of maintaining ESW systems in a manner that precludes the development of potential common cause failure vulnerabilities due to inadequate water chemistry. Licensees are required to have an operable ESW system as specified in plant technical specifications. In addition, licensees are required to satisfy the requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 to ensure: changes to chemistry procedures are adequately evaluated with respect to fouling and scaling so that ESW system heat exchangers meet design basis requirements; and, testing is adequate to identify an unacceptable degree or rate of heat exchanger degradation while providing for the timely evaluation of test results to allow for timely corrective actions.

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.

/RA by TQuay for/

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