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

January 20, 2006

NRC INFORMATION NOTICE 2005-26, SUPPLEMENT 1: ADDITIONAL RESULTS OF CHEMICAL EFFECTS TESTS IN A SIMULATED PWR SUMP POOL ENVIRONMENT

ADDRESSEES

All holders of operating licenses for pressurized-water reactors (PWRs), except those who have permanently ceased operations and have certified that fuel has been permanently removed from the reactor.

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees about recent NRC-sponsored research results related to chemical effects in a simulated PWR sump pool environment. This supplement specifically provides additional information regarding test results related to chemical effects in environments containing dissolved phosphate, (e.g., from trisodium phosphate (TSP)), and dissolved calcium. NRC anticipates that recipients will review the information for applicability to their facilities and consider taking actions, as appropriate, to avoid similar issues. However, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

NRC opened Generic Safety Issue 191 (GSI-191), "Assessment of Debris Accumulation on Pressurized-Water Reactor (PWR) Sump Performance," because debris accumulation on PWR sump screens may affect the emergency core cooling system pump net positive suction head margin. To address GSI-191, NRC issued Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors," and Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." GL 2004-02 requests, in part, that licensees evaluate the maximum head loss postulated from debris accumulation (including chemical effects) on the submerged sump screen. Chemical effects are corrosion products, gelatinous material, or other chemical reaction products that form as a result of interaction between the PWR containment environment and containment materials after a loss-of-coolant accident (LOCA). NRC and the nuclear industry jointly developed an integrated chemical effects test (ICET) program to determine if chemical reaction products can form in representative PWR post-LOCA containment pool environments. These tests were conducted by Los Alamos National Laboratory at the University of New Mexico. The ICET series involved five tests, each representing a different post-LOCA environment, that are broadly representative of existing PWR plant conditions. Although chemical products were

observed in all of the ICET environments, evaluating the head loss associated with these products was outside the scope of the ICET program. NRC initiated additional testing to obtain insights on the head loss associated with some chemical products that may form in PWR containment pools. Initial results from head loss testing performed at the Argonne National Laboratory (ANL) were provided in NRC IN 2005-26, dated September 16, 2005. ANL performed these tests in a simulated containment pool environment that was buffered with TSP and contained calcium silicate insulation (cal-sil). These tests were intended to recreate calcium phosphate precipitates observed in the ICET 3 environment and measure the head loss effect. Testing at ANL was conducted in a closed, unpressurized vertical test loop with NUKON fiberglass and cal-sil particulate first deposited on a test screen. Subsequently, dissolved calcium was introduced to react with the TSP buffer to create calcium phosphate. In these initial tests, calcium phosphate precipitate led to significant head loss for the conditions evaluated.

Subsequent to the issuance of IN 2005-26, three additional sets of tests were conducted at ANL: (1) head loss tests in a borated solution containing TSP, NUKON fiberglass, and varying concentrations of either dissolved calcium or cal-sil, (2) calcium phosphate settling tests performed in a static water column, and (3) dissolution tests to determine the dissolved calcium concentrations produced by various cal-sil amounts and the effect of TSP addition rate on cal-sil dissolution. Details from these tests are contained in an attachment, "Chemical Effects Head Loss Testing, Quick Look Report Tests ICET 3-4 to 3-11," (ML060190709) dated January 20, 2006.

DISCUSSION

As part of the mechanistic evaluation discussed in GL 2004-02, licensees are required to evaluate the sump screen head loss consequences of any chemical effects in an integrated manner with other postulated post-LOCA conditions. The most recent research results confirm that a simulated containment pool environment containing phosphate and dissolved calcium can rapidly produce calcium phosphate precipitate that can significantly increase head loss if transported to a fiber bed covered screen. Highlights from the attached report include the following:

- Initial testing with a debris bed of 0.33 kilograms per square meter (kg/m^2) NUKON fiberglass and 1.19 kg/m^2 cal-sil (0.2 grams per liter (g/L) cal-sil concentration) resulted in a significant pressure drop across the test screen in both a baseline test without chemical products and when TSP was present to form calcium phosphate precipitate. Therefore, subsequent head loss tests were performed with lower cal-sil concentrations to more clearly evaluate chemical effects related to calcium phosphate formation.

- Test results with a debris mixture consisting of 0.71 kg/m^2 of NUKON fiberglass and either 0.71 kg/m^2 of cal-sil (0.13 g/L cal-sil concentration) or an equivalent dissolved calcium concentration from calcium chloride showed a significant increase in pressure drop across the test screen attributed to the formation of calcium phosphate precipitate.

- Test parameters (e.g., amount of cal-sil dissolution prior to debris bed formation, TSP addition rates) were varied to investigate how the relative timing of calcium phosphate formation and the arrival sequence with respect to other debris affected head loss. Significant head loss occurred most quickly for tests that represented the maximum

cal-sil dissolution rates (i.e., instantaneous through calcium chloride addition) and had the greatest amount of calcium phosphate present initially. Although the head loss increased less rapidly in tests with less initial calcium phosphate precipitate, the head loss eventually approached the steady state values of the tests with maximum initial calcium phosphate.

- Tests performed with incremental calcium chloride addition suggest a strong nonlinear relationship between the amount of calcium phosphate precipitate and the pressure drop. For the ANL test loop configuration and test conditions (e.g., TSP concentration, debris loadings, etc.) dissolved calcium concentrations equal to or greater than 25 parts per million (ppm) caused a rapid and significant pressure drop increase.

- Settling tests were performed to assess the settling rate of calcium phosphate precipitate under conditions with no bulk directional flow. Precipitate agglomeration was observed at higher concentrations (300 ppm) of calcium phosphate and approximately 50 percent of the precipitate settled more rapidly (3.8 cm/min) at these concentrations. At lower concentrations (75 ppm) precipitate agglomeration was not observed and the settling velocity was estimated to be 0.8 cm/min.

- The dissolution of cal-sil was slowed by instantaneous TSP dissolution at higher (1.5 g/L) cal-sil concentrations. However, the cal-sil dissolution rate (for the concentrations evaluated) is not strongly dependent on the TSP dissolution rate within the range of complete TSP addition between one and four hours. Although complete dissolution of the cal-sil took up to 4 or more days under some test conditions, the equivalent dissolved calcium concentrations reached 75 ppm within a few hours for cal-sil concentrations down to 0.5 g/L.

The information provided in the attachments to IN 2005-26 and this supplement are relevant to plants containing phosphate (e.g., plants using TSP as a containment pool buffering agent) and calcium containing materials (e.g., insulations, concrete) that could dissolve within the post-LOCA containment pool to form calcium phosphate precipitate. These test results confirm that substantial head loss can occur if sufficient calcium phosphate is produced in a containment pool and is transported to a sump screen along with fibrous insulation debris.

Although NRC observed significant increases in head loss because of chemical effects, it is important to note that these head loss results were obtained in a recirculating test loop in which virtually all chemical products were transported to the test screen. These tests were not intended to be prototypical of a PWR plant containment. In similar plant containment pool environments, chemical product formation, transport, and subsequent head loss will be a function of several variables including: the cal-sil (or other calcium containing materials) debris concentration within the pool, the calcium dissolution rate, the TSP dissolution rate, the containment pool velocity profiles and fluid approach velocity at the sump screen, the LOCA break location, the containment fluid recirculation time, the containment pool temperature history, the containment floor layout and location of TSP baskets, the sump screen debris loading, and the sump screen design.

The NRC is continuing head loss testing in simulated PWR containment pool environments that use other chemicals to buffer pH.

CONTACTS

This information notice does not require any 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.

Christopher I. Grimes, Director ***/RA/***
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contacts: Paul Klein, NRR
301-415-4030
E-mail: pak@nrc.gov

Robert Tregoning, RES
301-415-6657
E-mail: rlt@nrc.gov

Attachment:
Chemical Effects/Head-Loss Testing Quick Look Report, Tests 1 and 2 (ML060190709)

The NRC is continuing head loss testing in simulated PWR containment pool environments that use other chemicals to buffer pH.

CONTACTS

This information notice does not require any 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.

Christopher I. Grimes, Director ***/RA/***
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contacts: Paul Klein, NRR
301-415-4030
E-mail: pak@nrc.gov

Robert Tregoning, RES
301-415-6657
E-mail: rlt@nrc.gov

Attachment:
Chemical Effects/Head-Loss Testing Quick Look Report, Tests 1 and 2 (ML060190709)

Note: NRC Generic Communications may be found on the NRC public website, http://www.nrc.gov under Electronic Reading Room/Document Collections.

DISTRIBUTION:
IN File

ADAMS ACCESSION NUMBERS: Package - ML060170076, IN - ML060170102

OFFICE	OES:IREB:DIRS	TECH EDITOR	CSGB	CSGB	DCI	DSS
NAME	ICJung	HChang	PAKlein	AHiser EMurphy for	WHBateman	JNHannon
DATE	01/19/2006	01/18/2006	01/19/2006	01/18/2006	01/19/2006	01/19/2006

OFFICE	RES	PGCB:LA	PGCB:DPR	BC:PGCB:DPR	D:DPR
NAME	RTregoning	CHawes	DBeaulieu	CJackson CGrimes for	CGrimes
DATE	01/19/2006	01/19/2006	01/20/2006	01 /20 /2006	01 /20 /2006

OFFICIAL RECORD COPY