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

November 19, 1987

NRC INFORMATION NOTICE NO. 86-108, SUPPLEMENT 2: DEGRADATION OF REACTOR COOLANT SYSTEM PRESSURE BOUNDARY RESULTING FROM BORIC ACID CORROSION

Addressees:

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose:

This supplement to Information Notice (IN) 86-108 is intended to provide addressees with additional information concerning potential problems resulting from the boric acid-induced corrosion of ferritic steel components of systems important to safety. 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 information notice do not constitute NRC requirements; therefore, no specific action or written response is required.

Description of Circumstances:

On August 7, 1987, after an unplanned shutdown, Salem Unit 2 was brought to a cold shutdown condition.

Inspection teams entered the containment building to look for reactor coolant leaks that would account for the increased radioactivity in containment air that was noted before the shutdown. The team assigned to the reactor head area found boric acid crystals on a seam in the ventilation cowling surrounding the reactor head area. The licensee then removed some of the cowling and insulation and discovered a mound of boric acid residue at one edge of the reactor vessel head. A pile of rust-colored boric acid crystals 3 feet by 5 feet by 1 foot high had accumulated on the head, and a thin white film of boric acid crystals had coated several areas of the head and extended 1 to 2 feet up the control rod mechanism housings. The source of the boric acid was reactor coolant leakage through three pinholes in the seal weld at the base of the threaded connection (conoseal) for thermocouple instrumentation. During the previous operating period, reactor coolant leakage had not exceeded 0.4 gallon per minute (gpm).

Corrosion damage to the reactor vessel head was caused by borated water that had dripped from the ventilation supports onto the head. The licensee found nine corrosion pits in the ferritic steel vessel head. The pits were 1 to 3 inches in diameter and 0.4 to 0.36 inch deep. In the corroded area, the minimum thickness of the head as specified by design could have been 7 inches, while the actual wall thickness was 8 inches. Calculations performed by the licensee and Westinghouse confirmed that the affected areas still met ASME Code requirements.

Another incident of boric acid corrosion, which occurred at San Onofre Unit 2, was reported on August 31, 1987. With the plant shut down and the reactor coolant temperature at 125°F, the control room operator was attempting to change valve positions in the shutdown cooling system, when he found that an isolation valve in a 10-inch pipe was stuck closed. Personnel were sent into the containment to manually open the valve with a pipe wrench. During an attempt to open the valve, the valve packing follow plate was dislodged when the carbon steel holddown bolts, corroded by previous boric acid leakage, failed. The reactor coolant system pressure, which was 350 psig, caused the valve packing to extrude. A leak of 60 to 100 gpm developed and 18,000 gallons of reactor coolant spilled into the containment and was subsequently pumped to the liquid radwaste system. Five workers were contaminated. The concentration of radioactive gases at the site boundary reached 17 percent of the permissible concentration for noble gases.

Discussion:

As a consequence of the accelerated rate of the boric acid corrosion observed at the Salem plant and the extensive corrosion previously reported at Turkey Point Unit 4 (discussed in Information Notice 86-108, Supplement 1), Westinghouse issued letters to its customers, on or about October 15, 1987, which addressed the potential for degradation of the reactor coolant system pressure boundary resulting from boric acid corrosion and enclosed a report entitled "Corrosion Effects of Boric Acid Leakage on Steel Under Plant Operating Conditions - A Review of Available Data." The following are excerpts from that report.

> As a result of the recent boric acid leakage at reactor vessel head penetrations at the Turkey Point 4 and Salem 2 stations, Westinghouse has reviewed available literature and has conducted certain experiments regarding the corrosion effects of such leakage on the reactor vessel steels and stud materials.
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> The primary effect of boric acid leakage that can concentrate is 'wastage' (or general dissolution corrosion) of both carbon steel and stainless steel. Pitting, stress corrosion cracking (SCC), intergranular attack, and other forms of corrosion are not generally of concern in concentrated boric acid solutions at elevated temperatures. It should be recognized, however, that the general corrosion rate (wastage) of carbon steel can be unacceptably high under conditions that can prevail when primary coolant leaks onto surfaces and concentrates at the temperatures that pertain to reactor external surfaces. In

one series of tests performed by Westinghouse, aerated 25 percent boric acid solutions were shown to corrode carbon steel at about 400 mils/month in a 200 degrees F environment. Deoxygenating the test solution reduced the corrosion rate to 250 mils/month. Similar corrosion rates (358-418 mils/month) were obtained by dripping 15 percent boric acid at 200 degrees F onto carbon steel surfaces at 210 degrees F in air. Both types of experiments demonstrate that aqueous solutions of boric acid, when allowed to concentrate, are highly corrosive to carbon steel surfaces that are at approximately 200 degrees F.

In one series of Westinghouse tests relating to leakage of boric acid, a mock-up of the Inconel control rod drive mechanism (CRDM) head weld with a typical crevice geometry, was exposed to dripping 15 percent boric acid at 210 degrees F. Extensive general corrosion of the steel occurred (to approximately 400 mils/month), but there was no preferential attack in the crevice or on the Inconel.

The information provided by Westinghouse confirmed and supplemented the evidence that recently observed boric acid corrosion rates are greater than those that were either previously known or estimated. A review of existing inspection programs may be warranted to ensure that adequate monitoring procedures are in place to detect boric acid leakage and corrosion before it could result in significant degradation of the reactor coolant pressure boundary. The information herein is being provided as an early notification of a potentially significant matter that is still under consideration by the NRC staff. If NRC evaluation so indicates, specific licensee actions may be requested.

No specific action or written response is required by this information notice. If you have any questions about this matter, please contact the technical contact listed below or the Regional Administrator of the appropriate regional office.

Charles E. Rossi

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contact: Sam MacKay, NRR
(301) 492-8394

Attachment: List of Recently Issued NRC Information Notices