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

December 20, 1996

NRC INFORMATION NOTICE 96-69: OPERATOR ACTIONS AFFECTING REACTIVITY

Addressees

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

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to operating events that have affected reactivity. 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 are not NRC requirements; therefore, no specific action or written response is required.

Background

Generic Letter 85-05, "Inadvertent Boron Dilution Events," dated January 31, 1985, was used to indicate the staff's position that resulted from the evaluation of Generic Issue 22, "Inadvertent Boron Dilution Events." The generic letter considers an unmitigated boron dilution event as a serious breakdown in the licensee's ability to control its plant and strongly urges each licensee to assure itself that adequate protection against boron dilution events exists in its plants. However, the consequences are not severe enough to warrant backfitting requirements for boron dilution events at operating reactors.

In the past several years, this year in particular, there have been numerous events where operator actions inappropriately affected reactivity. This information notice highlights several recent events in which poor command and control during reactivity evolutions have led to unanticipated conditions.

Description of Circumstances

Byron Unit 1

On June 12, 1996, the licensee made four dilutions of the reactor coolant system. Only the first dilution was calculated in advance. At the time, Byron Unit 1 was in cold shutdown for a refueling outage. Fuel had been reloaded into the core, and the reactor head was in position. The reactor coolant loops were isolated to support steam generator tube inspection and repair. The reactor coolant system (RCS) boron concentration was 1,984 parts per million (ppm). The RCS silica concentration was elevated at 4 ppm.

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A series of dilutions was planned to reduce silica levels and bring the RCS boron concentration closer to the 1,600 ppm starting point for the planned dilution to criticality. The target RCS boron concentration was 1,700 ppm.

The operations staff added approximately 7,600 liters [2,000 gallons] of pure, unborated water from the primary water storage tank through a feed-and-bleed dilution. A reactor operator calculated the expected boron concentration after this dilution to be no less than 1,837 ppm. The subsequent chemistry sample results indicated a boron concentration of 1,942 ppm.

On the basis of the chemistry sample result, the reactor operators performed a second dilution of 7,600 liters [2,000 gallons] without conducting formal calculations expecting to achieve a boron concentration of around 1,800 ppm. The chemistry sample after the second dilution indicated a boron concentration of 1,877 ppm. Based on this and a subsequent chemistry sample, but without formal calculations, the reactor operators made two additional dilutions of 15,200 liters [4,000 gallons] each, expecting a final boron concentration of greater than 1,700 ppm. The chemistry sample results after the fourth dilution indicated a boron concentration of 1,521 ppm. The reactor operators added borated water to increase the boron concentration to about 1,585 ppm to ensure adequate shutdown margin. The licensee's Technical Specifications require a 1.3-percent shutdown margin, which the licensee indicated was about 1,164 ppm boron.

The licensee determined that the sample line was not adequately purged before the first three samples were obtained. However, the sample valve was left open for about 1 hour before the fourth sample was taken, which allowed the line to be adequately purged; thus a representative sample was obtained.

Washington Nuclear Project No. 2

On June 27, 1996, the reactor achieved criticality at Step 8-3 in the rod pull sequence. Criticality was expected at Step 12-18 of the rod pull sequence, with an acceptable range of achieving criticality (+/- 10 $mk_{effective}$) between Steps 11-12 and 14-20. Achieving criticality at Step 8-3 was outside the licensee's self-imposed acceptable range of values and was approximately 16 $mk_{effective}$ before the calculated estimated critical position. In accordance with plant procedures, operators manually inserted control rods to shut down the reactor.

The estimated critical position calculated for the startup was performed using an inappropriate parameter for the plant conditions. The nuclear engineer selected an incorrect parameter for xenon dependence. The reactor was shutdown for a short period of time and xenon did not completely decay and was incorrectly accounted for in the calculation.

During the approach to criticality, members of the control room staff were involved with activities related to shift turnover, this may have distracted personnel involved with the startup.

St. Lucie Unit 1

On January 22, 1996, while performing a routine manual boron dilution of the reactor coolant system, the board reactor controls operator (RCO) was distracted leading to an over dilution with reactor power reaching 101 percent. During the evolution the RCO responded to a secondary plant annunciator and lost track of the routine dilution. He then requested to be relieved by the desk RCO while he prepared his lunch. During the turnover, there was no discussion of the dilution in progress which continued for seven minutes until the board RCO returned and realized his error. The operators took prompt corrective action of stopping the dilution and initiating manual boration.

Discussion

At Byron, an inadequate sampling procedure and inadequate calculations of boron concentration led to an unexpected dilution of 179 ppm below the target boron concentration of 1,700 ppm. The licensee determined the chemistry sample procedure to be deficient. This deficiency was originally noted during review of procedures for post-accident sampling; however, the chemistry staff failed to recognize the implications on routine sampling. The licensee's dilution procedure was deficient, also, in that it did not have provisions for dilutions with the loop stop isolation valves closed. The operators calculated the reduced volume for the dilution calculations and attributed the differences in expected and sample boron concentrations to the conservative reactor coolant system volume used in the calculation. The reactor operators continued with successive dilutions based on the original calculation and the sample concentrations but failed to adequately question the higher than expected sample values and to perform acceptable calculations between dilutions in order to determine the additional dilution amounts.

At Washington Nuclear Project No. 2, Shift Nuclear Engineers, because of inadequate training on a recent software modification, incorrectly selected a parameter which resulted in the wrong estimated critical position. These engineers and operators suspected a problem with the estimated critical position but did not effectively resolve their concerns or express them to higher management. The engineers did perform an independent verification which confirmed the estimated value; however, they used the same software and input parameters.

During the startup, the control room staff realized that the reactor would go critical outside their self-imposed +/- 10 $mk_{effective}$ reactivity band; however, they continued the startup because of their interpretation of a poorly written startup procedure. The likelihood of achieving early criticality was not communicated to upper management, either. When criticality was achieved, operators then acted conservatively and manually shut down the reactor.

At St. Lucie Unit 1, the board RCO exhibited inattentiveness to a routine evolution affecting reactivity. The RCO initiated the dilution without notifying other control room personnel and failed to discuss the evolution in progress with his temporary replacement prior to exiting the

control room. As a result, the senior reactor operator and the other operators were unaware that a reactivity addition was taking place. Upon returning to the control room, the RCO noted an alarm which was due to increasing reactor coolant system pressure, realized his error, and took prompt corrective actions.

Both the Byron and the Washington Nuclear Project events involved a lack of questioning attitude that would have allowed the operators to suspend the ongoing evolutions affecting reactivity until they had an understanding of the unexpected plant indications. Furthermore, all three events contained inappropriate command and control over activities associated with reactivity manipulations.

Additional details of these events can be found in the following inspection reports: Byron Unit 1 IR 50-454/96-05; 50-455/96-05 dated July 31, 1996 [9608120029]; Washington Nuclear Project No. 2 IR 50-397/96-16 dated September 12, 1996 [9609190275]; and St. Lucie IR 50-247/96-03 dated February 22, 1996 [9607150294].

This information notice requires no specific action or written response. If you have any questions about the information in this notice, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

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LIST OF RECENTLY ISSUED NRC INFORMATION NOTICES

Information Notice No.	Subject	Date of Issuance	Issued to
96-68	Incorrect Effective Diaphragm Area Values in Vendor Manual Result in Potential Failure of Pneumatic Diaphragm Actuators	12/19/96	All holders of OLs or CPs for nuclear power reactors
96-67	Vulnerability of Emergency Diesel Generators to Fuel Oil/Lubricating Oil Incompatibility	12/19/96	All holders of OLs or CPs for nuclear power reactors
96-66	Recent Misadministrations Caused by Incorrect Calibrations of Strontium-90 Eye Applicators	12/13/96	All U.S. Nuclear Regulatory Commission Medical Use Licensees authorized to use strontium-90 (Sr-90) eye applicators
96-65	Undetected Accumulation of Gas in Reactor Coolant System and Inaccurate Reactor Water Level Indication During Shutdown	12/11/96	All holders of OLs or CPs for nuclear power reactors
96-64	Modifications to Containment Blowout Panels Without Appropriate Design Controls	12/10/96	All holders of OLs or CPs for nuclear reactors

OL = Operating License
CP = Construction Permit