NUCLEAR REGULATORY COMMISSION

Proposed Generic Communication

Control Rod Insertion Problems

AGENCY: Nuclear Regulatory Commission

ACTION: Notice of opportunity for public comment

SUMMARY: The Nuclear Regulatory Commission (NRC) is proposing to issue a bulletin supplement that will request addressees to take actions to ensure the continued operability of the control rods. These actions will ensure that adequate shutdown margin is maintained and that the control rods will satisfactorily perform their intended function of effectively terminating the fission process during all operating conditions in accordance with the current licensing basis for each facility. The NRC is seeking comment from interested parties regarding both the technical and regulatory aspects of the proposed bulletin supplement presented under the Supplementary Information heading.

The proposed bulletin supplement has been endorsed by the Committee to Review Generic Requirements (CRGR). The relevant information that was sent to the CRGR will be placed in the NRC Public Document Room. The NRC will consider comments received from interested parties in the final evaluation of the proposed bulletin supplement. The NRC's final evaluation will include a review of the technical position and, as appropriate, an analysis of the value/impact on licensees. Should this bulletin supplement be issued by the NRC, it will become available for public inspection in the NRC Public Document Room.

DATES: Comment period expires [30 days after FRN is published]. Comments submitted after this date will be considered if it is practical to do so, but assurance of consideration cannot be given except for comments received on or before this date.

ADDRESSEES: Submit written comments to Chief, Rules Review and Directives Branch, U.S. Nuclear Regulatory Commission, Mail Stop T-6D-69, Washington, DC 20555-0001. Written comments may also be delivered to 11545 Rockville Pike, Rockville, Maryland, from 7:30 am to 4:15 pm, Federal workdays. Copies of written comments received may be examined at the NRC Public Document Room, 2120 L Street, N.W. (Lower Level), Washington, D.C.

FOR FURTHER INFORMATION, CONTACT: Margaret S. Chatterton, (301) 415-2889

SUPPLEMENTARY INFORMATION:

NRC BULLETIN 96-01 SUPPLEMENT 1: CONTROL ROD INSERTION PROBLEMS

Addressees

This bulletin supplement is being sent to all holders of pressurized-water reactor (PWR) operating licenses (except those that have certified that they are permanently shutdown). It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, action is only requested from PWR licensees of Westinghouse and Babcock and Wilcox designed plants.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this supplement to Bulletin 96-01 to: (1) alert addressees to the issues concerning incomplete control rod insertion as a result of distortion of the thimble tubes, (2) request all licensees of Westinghouse and Babcock and Wilcox designed plants take actions to ensure the continued operability of the

control rods, and (3) require that all licensees of Westinghouse and Babcox and Wilcox designed plants send to the NRC a written response to this bulletin supplement relating to the actions and information requested in this supplement.

Background

Incomplete control rod insertion has been previously addressed by the NRC in Information Notice (IN) 96-12, "Control Rod Insertion Problems," dated February 15, 1996, and Bulletin 96-01, "Control Rod Insertion Problems," dated March 8, 1996. Bulletin 96-01 requested actions to ensure that all affected plants respond in a proactive manner to recent industry experience and support data collection that permitted the staff to more effectively assess this issue and determine whether further regulatory action was needed. Since Bulletin 96-01 was issued, there has been extensive investigation of the issue, including evaluation of plant data (trip, rod drop time, recoil and drag data), spent fuel pool testing, Zircaloy material property review, and review of worldwide experience.

Description of Circumstances

South Texas Project

On December 18, 1995, with South Texas Unit 1 at 100-percent power, a pilot wire monitoring relay actuation caused a main transformer lockout, which resulted in a turbine trip and a reactor trip. While verifying that control rods had inserted fully after the trip, operators noted that the rod bottom lights of three control rod assemblies were not lit; the digital rod position indication for each rod indicated six steps withdrawn. A step is equivalent to 1.59 cm (5/8 inch), and the top of the dashpot begins at 38 steps. One rod drifted into the fully inserted rod bottom position within 1 hour, and the

other two rods were manually inserted later. During subsequent testing of all control rods in the affected banks, the rod position indication for the same three locations, as well as a new location, indicated six steps withdrawn. As compared to prior rod drop testing, no significant differences in rod drop times were noted before reaching the upper dashpot area for any of the control rods. Within 1 hour after the rod drop tests, two of the rods drifted to the rod bottom position and the other two were manually inserted. All four control rods were located in XLR fuel assemblies, which were in their third cycle, with burnup greater than 42,880 megawatt days per metric ton uranium (MWD/MTU).

Wolf Creek Plant

On January 30, 1996, after a manual scram from 80-percent power, five control rod assemblies at the Wolf Creek plant failed to insert fully. Two rods remained at 6 steps withdrawn, two at 12 steps, and one at 18 steps. At Wolf Creek, a step is equivalent to 1.59 cm (5/8 inch) and the top of the dashpot begins at approximately 30 steps. Three of the affected rods drifted to the fully inserted position within 20 minutes, one within 60 minutes, and the last one within 78 minutes. The results also indicate that there was some slowing down of affected rods before they reached the dashpot. After the scram, the licensee initiated emergency boration because all rods did not insert fully. During subsequent cold rod drop tests, the same five rods, plus an additional three rods, failed to fully insert. All of the affected rods were in 17x17 VANTAGE 5H fuel assemblies, with burnup greater than 47,600 MWD/MTU.

North Anna Plant

On February 21, 1996, during the insert shuffle in preparation for loading North Anna Unit 1, Cycle 12, two new control rod assemblies could not be removed with normal operation of the handling tool from the fuel assemblies in the spent fuel pool in which they were temporarily stored. The control rod assemblies were removed using the rod assembly handling tool in conjunction with the bridge crane hoist. The two affected fuel assemblies were VANTAGE 5H assemblies, which had achieved burnups of 47,782 MWD/MTU and 49,613 MWD/MTU during two cycles of irradiation.

At both South Texas units, a 14-foot active fuel length core design is used. Several differences between the standard 12-foot active fuel design and the 14-foot design are as follows: the 14-foot fuel design is approximately 76.2 cm (30 inches) longer than the standard fuel assembly design, it has 10 mid-grids compared to 8, and the dashpot region is 25.4 cm (10 inches) longer and comprises a double dashpot. The control rod radial clearances above and in the dashpot region of the 14-foot fuel assembly are similar to those of the standard design. The South Texas core contained three different 17x17 fuel types-Standard XL, Standard XLR, and VANTAGE 5H-all of which are designed and fabricated by Westinghouse. The core contained 57 control rods, all of which are silver-indium-cadmium rods. The four affected rods were found in twice-burned Standard XLR fuel assemblies.

During subsequent testing, the rod drop traces revealed no significant change in dashpot entry time; however, the affected rods did not show recoil on the rod drop trace. Recoil is a dampening effect that is normally seen in the traces as a result of contact of the control rod assembly spider hub spring with the fuel assembly. The testing of similar rods in Unit 2 revealed

no adverse indications. One rod showed no recoil but inserted fully into the core.

When rod drop tests were performed at South Texas Unit 1 on March 4, 1996, seven rods failed to fully insert. The stuck rods were in fuel assemblies with burnups from 43,500 to 47,500 MWD/MTU. All seven stopped at 6 steps from the bottom. Again there was no significant degradation in the rod drop times.

During end-of-cycle (Unit 1 Cycle 6) rod drop tests on May 18, 1996, 11 rods did not fully insert; 9 stuck at six steps and 2 stuck at twelve steps. Two of the rods were in fuel assemblies with lower burnups - 32,200 and 35,400 MWD/MTU.

Mid-cycle (Unit 1 Cycle 7) testing was performed on January 25, 1997, when the burnup reached approximately 32,000 MWD/MTU on the most burned rodded assembly in the new cycle. During this test two rods stuck at six steps. Both control rods were located in V5H fuel assemblies, which were in their second cycle with burnups of 26,100 and 27,400 MWD/MTU.

On February 8, 1997 when South Texas Unit 2 shutdown for refueling, four rods stuck at six steps and one rod stuck at twelve steps. The associated fuel assembly burnups were 39,800 to 52,700 MWD/MTU. Four of these five rods had shown zero or one recoil during rod drop testing in January 1996. Although all rod drop times were within technical specification limits, increases in rod drop times were observed for some rods. Examination of the rod drop traces showed marked differences from previous normal traces. Thus indicating resistance above the dashpot area.

At Wolf Creek, subsequent cold, full-flow testing of all of the control rod assemblies indicated that eight control rods, including the five control

rods that did not fully insert following the reactor trip on January 30, 1996, did not fully insert when tripped. One control rod in core location H2 paused at 96 steps, stopped at 90 steps, and slowly inserted to 30 steps over the next 2 hours. The control rod was then manually inserted. The seven other affected rods stopped at various heights in the dashpot region, five of which fully inserted within 22 minutes. One of the other two drifted to the bottom within 1.5 hours; the remaining rod needed to be manually inserted. The remaining 45 rods fully inserted when dropped, although a number of them did not exhibit the expected number of recoils. Of the total 53 control rod assemblies, the assembly at core location H2 (the only rod stopping outside the dashpot region) was a hafnium control rod; the remaining were silver-indium-cadmium control rod assemblies. However, subsequent inspection of the hafnium rod did not indicate any adverse dimensional change. The licensee retested all rods that stuck, as well as those rods that failed to recoil more than twice, and the results were similar to the results of the previous testing.

At North Anna, the two affected control rods were removed and were inserted into a series of other fuel assemblies. No additional binding was observed. However, difficulty was experienced when another control rod was inserted into the two affected fuel assemblies. On the basis of this result, the licensee determined that the cause of the binding was related to the fuel assemblies and not the control rods. Subsequent control rod drag testing data indicated a correlation of control rod drag force to assembly burnup and a significant increase in drag force at assembly burnups greater than 45,000 MWD/MTU.

Regulatory Requirements and Guidance

10 CFR Part 50, Appendix B, Section XI, "Test Control" requires that "a test program shall be established to assure that...structures, systems, and components will perform satisfactorily..." The requested actions described below will assure that adequate shutdown margin is maintained and that the control rods will satisfactorily perform their intended function of effectively terminating the fission process during all operating conditions in accordance with the current licensing basis for each facility.

Regulatory guidance for the control rods is stated in General Design Criterion (GDC) 26, of Appendix A to 10 CFR Part 50, "Reactivity Control System Redundancy and Capability," of Appendix A to 10 CFR Part 50 which specifies "Two independent reactivity control systems of different design principles shall be provided. One of the systems shall use control rods, preferably including a positive means for inserting the rods, and shall be capable of reliably controlling reactivity changes to assure that under conditions of normal operation, including anticipated operational occurrences, and with appropriate margin for malfunctions such as stuck rods, specified acceptable fuel design limits are not exceeded."

In addition, GDC 29 "Protection against anticipated operational occurrences," states that the protection and reactivity control systems shall be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.

Worldwide experience of incomplete control rod insertion problems (other than those caused by debris, foreign material, or control rod drive mechanism problems) has shown that the primary cause was thimble tube distortion caused by excessive compressive loads. This problem has been limited to fuel designs

that incorporate small-diameter (approximately 0.5 inch) thimble tubes. Current data show that distortion significant enough to cause incomplete insertion has not occurred below certain burnup levels. Thus small-diameter thimble tube fuel designs are considered acceptable up to those burnup levels. In order to meet the current licensing basis for each facility, the ability to insert the control rods needs to be demonstrated for burnups that exceed these burnup levels. This ability can be demonstrated through testing at intervals or by a rigorous engineering analysis.

Discussion

The root cause explanation for the Wolf Creek event was that the increased compressive load was caused by greater than expected fuel assembly growth. The phenomenon appears to be dependent on a number of factors, including burnup, temperature, and power history, the interaction of which is not clearly understood. Nothing in this root cause explanation would preclude other fuel designs from exhibiting similar behavior at different combinations of burnup, power history, and core exit temperature. In addition, unknown factors may also contribute to the observed behavior.

The root cause of the incomplete control rod insertions at South Texas Project has been identified as excessive fuel assembly guide tube distortion in the dashpot. The reason for the distortion is inadequate resistance to buckling in the fuel assembly design under required loads and burnup.

The NRC staff has evaluated the data obtained as a result of Bulletin 96-01 and determined that while most of the high drag data has been in high-temperature plants, there have been a number of cases of high drag in lower temperature plants. High drag has been correlated with thimble tube distortion. Thus, it is not clear that plants with lower temperatures are not

susceptible to thimble tube distortion, which can lead to incomplete control rod insertion.

Although fuel with intermediate flow mixing grids (IFMs) would appear to be stiffer and thus less susceptible to distortion, it has not been shown that this fuel is not susceptible to thimble tube bowing from compressive loads. Furthermore, since the mid-spans would be strengthened, the top and bottom spans might be the most susceptible portions of the fuel assembly and distortion of the top span could lead to control rods sticking very high in the core. Thus, the staff still considers this fuel susceptible to thimble tube distortion which can lead to incomplete control rod insertion.

Although incomplete control rod insertion has only been experienced in a small number of fuel assembly designs to date, the NRC staff believes that all designs that incorporate small-diameter thimble tubes need to be examined, since these small-diameter thimble tubes appear to be susceptible to distortion and thus susceptible to control rod binding problems at high burnup levels.

Bulletin 96-01 requested actions through calendar year 1996 only. However, the staff believes that continued actions, as stated in this supplement, are necessary in order to resolve the concerns about small-diameter thimble tube distortion leading to incomplete control rod insertion.

While the tests performed in response to Bulletin 96-01 did not reveal any additional incomplete control rod insertions and all rod drop times measured met the Technical Specification limits for drop times to top of the dashpot, there were other disturbing results. The drag measurements resulted in dashpot drag above the criteria in three plants and higher than normal drag in an additional six plants. Thimble tube measurements were above the

criteria in six plants and high in three other plants. In addition, during measurements in the spent fuel pool control rods could not be fully inserted under their own weight in several plants.

Safety Assessment

The staff considers the potential for thimble tube distortion caused by high burnup and excessive compressive loads, leading to incomplete control rod insertion, a safety issue. In the absence of corrective actions that clearly eliminate the problem, the staff remains concerned about the ability to fully insert the control rods. The safety significance depends on the amount of shutdown margin lost because of incomplete control rod insertion. Were the control rods to stick high in the core, the reactor could not be shut down by the control rods, and other means, such as emergency boration, would be required.

At this time, the NRC staff considers all fuel designs that incorporate a small-diameter thimble tube to be potentially susceptible to thimble tube distortion caused by excessive compressive loads. Although the problem has only been observed in Zircaloy thimble tubes, the possibility of thimble tube distortion needs to be addressed for fuel assemblies incorporating other materials.

Requested Actions

In order to ensure the continued operability of the control rods, all licensees of Westinghouse and Babcock and Wilcox designed plants are requested to verify the full insertability and rod drop times by testing control rods in fuel assemblies with burnups greater than

35,000 MWD/MTU for assemblies without IFMs for 12 foot cores

40,000 MWD/MTU for assemblies with IFMs for 12 foot cores

25,000 MWD/MTU for assemblies in 14 foot cores

upon first reaching the limit(s) and approximately every 2,500 MWD/MTU until the end of cycle. In addition, end-of-cycle rod drop time tests and drag testing of all rodded fuel assemblies should be performed. Licensees are requested to submit their anticipated schedule for testing within 30 days of the date of this bulletin supplement. Within 30 days after completion of each set of testing, licensees are requested to submit a report that summarizes the data and documents the results obtained.

In order to meet the current licensing basis for each facility, the ability to insert the control rods needs to be demonstrated for burnups greater than those presented in the bulletin supplement. This ability can be demonstrated through testing at intervals specified above, or by a rigorous engineering analysis.

Required Response

Pursuant to Section 182a, the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f), all licensees of Westinghouse and Babcock and Wilcox designed plants must submit the following written information under oath and affirmation:

Within 30 days of the date of this bulletin supplement, a response indicating whether the requested actions will be taken and a schedule indicating when the actions will be performed. Licensees who choose not to take the requested actions must describe in their response any alternative course of action that they propose to take, including the basis for the acceptability of the proposed alternative course of action, and the schedule for completion of the alternative.

If, in the course of responding to this bulletin, a licensee determines that it is not in compliance with the Commission's rules and regulations, the licensee is expected to take corrective actions in accordance with the requirements of Section XVI of 10 CFR Part 50, Appendix B.

Address the required written responses to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001. In addition, submit a copy of the response to the appropriate regional administrator.

Related Generic Communications

NRC Information Notice 96-12, "Control Rod Insertion Problems"
NRC Bulletin 96-01, "Control Rod Insertion Problems"

Backfit Discussion

This bulletin supplement transmits an information request pursuant to the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f) to determine whether addressees are taking appropriate action to ensure continued operability of the control rods. To the extent that the actions requested herein by addressees are considered backfits, the backfits are justified under the compliance exception of the backfit rule, that is, 10 CFR 50.109(A)(4)(i).

10 CFR Part 50, Appendix B, Section XI, "Test Control" requires that "a test program shall be established to assure that...structures, systems, and components will perform satisfactorily..." The requested actions previously described will assure that adequate shutdown margin is maintained and that the control rods will satisfactorily perform their intended function of effectively terminating the fission process during all operating conditions in accordance with the current licensing basis for each facility.

The objective of the actions requested in this bulletin supplement is to verify that licensees are complying with the current licensing basis for the facility with respect to shutdown margin and control rod drop times. The issuance of the bulletin is justified on the basis of the need to verify compliance with the current licensing basis with respect to shutdown margin and control rod drop times.

Dated at Rockville, Maryland, this 13 day of May 1997

Seymour H. Weiss

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