Westinghouse Electric Corporation Power Systems

PWR Systems Division
Box 355
Pittsburgh Pennsylvania 15230

July 8, 1980
NS-TMA-2273

Mr. Victor Stello
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Phillips Building
7920 Norfolk Avenue
Bethesda, MD 20014

SUBJECT: Boron Dilution Concerns at Cold and Hot Shutdown

Dear Mr. Stello:

On June 27, 1980, Ed Jordan of your staff was notified by Westinghouse of an Unreviewed Safety Question under 10CFR50.59. This notification concerned the potential for an inadvertent boron dilution event while shutdown and operating on the Residual Heat Removal System. Attachment 1 is the text of the written notification supplied to our customers on July 8, 1980 which outlines potential Westinghouse concerns and the basis for recommended interim actions which address these concerns. These interim actions are somewhat modified from those previously reported. If there are any questions regarding the attached, please contact D. W. Call at 412/373-5074.

Very truly yours,

T. M. Anderson, Manager
Nuclear Safety Department

Attachment

cc: E. Jordan
R. Woods

B019
S 1/1
ADD: V. STELLO L E 1 1

8007210410 C

ATTACHMENT 1

On June 27, 1980, you were notified of certain Westinghouse concerns and recommended actions regarding the potential for an inadvertent boron dilution event at cold or hot shutdown conditions while on the Residual Heat Removal System. This notification was in accord with Westinghouse determination that these concerns constitute an Unreviewed Safety Question under 10CFR Part 50.59. The NRC Office of Inspection and Enforcement was also notified on June 27, 1980 that these concerns have generic applicability to Westinghouse-supplied nuclear power plants. Further clarification was made to the NRC Office of Inspection and Enforcement on June 30, 1980 that Westinghouse concerns are not applicable while the plant is greater than 5% shutdown.

This letter is intended to formally document these concerns and to provide additional relevant information. This letter also modifies the earlier recommended actions by a more detailed specification of applicable plant operating conditions.

Inadvertent boron dilution at shutdown has been generally regarded as an event which can be identified and terminated by operator action prior to a return to critical. Automatic protection has not been a standard feature for Westinghouse plants. Westinghouse has recently been conducting a general investigation of this potential event relative to the licensing requirements imposed on newer plants not yet in operation. This investigation is not yet complete. However, it has been determined that under certain shutdown conditions and with certain assumed dilution rates, adequate time for operator action to prevent a return to critical may not be available.

The current Westinghouse evaluations are based on plant conditions as noted below:

1. The Reactor Coolant System effective volume is limited to the vessel and the active portions of the hot and cold legs when on RHR, i.e., steam generator volumes are not included.

2. The plant is borated to a shutdown margin greater than or equal to 1% $\Delta k/k$.

3. Uniform mixing of clean and borated RCS water is <u>not</u> assumed, i.e., mixing of the clean, injected water and the affected loop is assumed but instantaneous, uniform mixing with the vessel, hot legs, and cold leg volumes upstream of the charging lines is <u>not</u> assumed. Thus a "dilution front" moves through the cold legs, downcomer, and lower plenum to the core volume as a single volume front. This results in subsequent decreases in shutdown margin due to dilution fronts moving through the active core region with a time constant equal to the loop transit time when on RHR (five to seven minutes).

If a return to critical occurs as a result of an inadvertent dilution, the following potential concerns have been identified:

1. A rapid, uncontrolled power excursion into the low and intermediate power ranges occurs, resulting in a power/flow mismatch due to the low flow (approximately 1 - 2% of nominal) provided by the RHR pumps.

2. The potential exists for significant system overpressurization. Pressure increases above the RHR cut off head (approximately 600 psig) further accentuate the effects of a power/flow mismatch when all RCS (RHR) flow is lost. An investigation of the adequacy of existing cold overpressurization protection systems is necessary in order to assess the full impact of this potential problem.

3. The potential exists for limited fuel damage. This is not currently a significant concern. Preliminary evaluation indicates that the potential for exceeding DNB limits is low due to the cold initial operating conditions. Further investigation of this problem is underway.

The recommended interim actions to prevent or mitigate an inadvertent boron dilution at shutdown conditions are detailed in Appendix A. If no cocked control rods are required, as specified in Figure A-1, the plant operator has fifteen minutes from the initiation of dilution event to terminate the event before a return to critical occurs. It is the Westinghouse position that a fifteen minute time interval from the initiation of the dilution to the time shutdown margin is lost is sufficient time for operator action. If cocked control rods are required, the source range reactor trip provides positive indication for immediate operator action to terminate dilution.

It is expected that the operator has available the following information for determination that a dilution event is in progress:

1. Source Range Neutron Flux with,

   a. High Flux at Shutdown Alarm set at half a decade above background.

   b. Use of the audible count rate indication to distinguish significant changes in flux, i.e., a doubling of the count rate.

   c. Periodic, i.e., frequent surveillance of the Source Range meters performed by the operator.

2. Status indication of the Chemical and Volume Control System and Reactor Makeup Water System with,

a. Indication of boric acid and blended (total) flow rate, or

b. Indication of boric acid and clean makeup flow rate,

c. CVCS valve position status lights, and

d. Reactor Makeup Water Pump "running" status light.

The operator action necessary upon determination that a dilution event is in progress (by High Flux at Shutdown Alarm, Source Range Reactor Trip, "P-6 Available" indication, high indicated or audible count rates, or make up flow deviation alarms) is:

1. Immediately open the charging/SI pump suction valves from the RWST (that open on receipt of an "S" signal). (For 312 plants these are LCV-115-B, D. For 412 plants these are LCV-112-D, E.)

2. Immediately close the charging/SI pump suction valves from the VCT (that close on receipt of an "S" signal). (For 312 plants these are LCV-115-C, E. For 412 plants these are LCV-112-B, C.)

3. For two-loop plants, immediately open the charging suction valves from the RWST. (For 212 plants these are LCV-113-B and LCV-112-C.) Also immediately close the charging suction valves from the VCT. (For 212 plants these are LCV-113-A and LCV-112-B.)

Through the use of Appendix A and the above noted operator action requirements, Westinghouse is attempting to minimize the operational burden placed on the plant to prevent or mitigate an inadvertent dilution event while maintaining adequate safety margin. Our investigation of this event is continuing. A detailed analytical model of the system response to a dilution event at shutdown conditions is being developed and the potential for system overpressurization and fuel failure will subsequently be assessed. The Westinghouse investigation is expected to be completed by September 15, 1980. We will keep you informed as to the results of our efforts.

APPENDIX A

Figure A-1, attached, provides the shutdown margin requirements as a function of Reactor Coolant System boron concentration and maximum possible dilution flow rate. Prior to use of this figure, the plant must determine the maximum dilution flow rate of all charging pumps not rendered inoperable once the plant is placed on RHR. To cover all modes, it should be assumed that the flow rate is based on pump runout unless there are flow limiting devices in the system (orifices, piping resistances, etc.). The Reactor Makeup Water pump capacity may be limiting in the determination of the maximum possible dilution flow rate.

Figure A-1 notes areas of acceptable operation of three different dilution flow rates as a function of RCS boron concentration and borated shutdown margin (K_{eff}). For a given dilution flow rate, if the RCS boron concentration and shutdown margin result in a point placed to the left of the flow rate line, no control rod bank withdrawal is necessary. If the results place the plant to the right of the line, then either the shutdown margin must be increased such that the plant is moded to the area of acceptable operation, or 1% $\Delta k/k$ in control rods must be withdrawn to provide additional shutdown margin. The tripping of the withdrawn rods provides positive operator indication that a dilution event is in progress and additional time for operator termination of the event. In all cases, a shutdown margin of 5% $\Delta k/k$ ($K_{eff} \leq 0.95$) is considered sufficient for continued operation without a requirement for control rod bank withdrawal.

Figure A-1 is based on best estimate calculations for the "all rods in" configuration. It is recommended that the Westinghouse Nuclear Design Report for your plant be used as a reference in determining the RCS boron concentration with the appropriate conservatism to be used in the figure. The Westinghouse Nuclear Fuel Division is available to provide assistance in meeting the constraints imposed by the Figure A-1 requirements.

Use of Figure A-1 is applicable any time there is boration/dilution capability from the normal boric acid blending system. The above procedure is not required if boration and/or makeup during cold and hot shutdown is performed utilizing water from the RWST. This requires that the normal dilution/boration path is isolated from the charging path. Two means of lockout to isolate the charging path are available:

1. Lock out Reactor Makeup Water Supply.

   This is accomplished by valve 8338 for 212 plants, valve 8457 for 312 plants, and valve 8455 for 412 plants.

OR:

2. Lock out valves between the boric acid blender and the VCT.

   These are FCV-111B, FCV-110B, 8339, 8355, and 8361 for 212 plants; FCV-114A, FCV-113B, 8454, 8441, and 8439 for 312 plants; FCV-111B, FCV-110B, 8453, 8441, 8439 for 412 plants.

This recommendation precludes the occurrence of an inadvertent dilution while borating or making up water from the RWS. under these conditions.

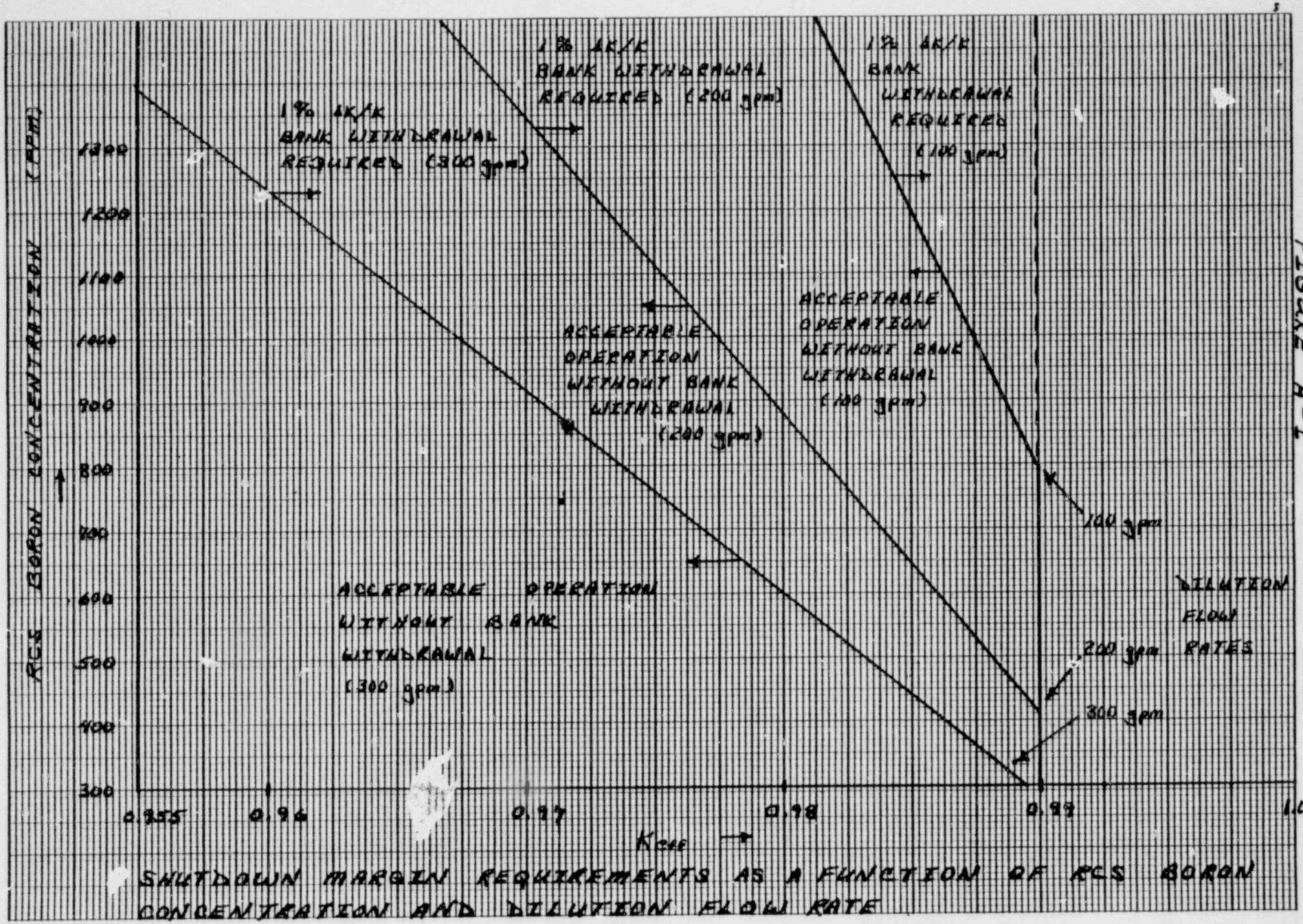

FIGURE A-1

SHUTDOWN MARGIN REQUIREMENTS AS A FUNCTION OF RCS BORON CONCENTRATION AND DILUTION FLOW RATE