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FACIL:50-316 Donald C. Cook Nuclear Power Plant, Unit 2, Indiana & 05000316

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SUBJECT: Forwards responses to questions raised by ANL at 840329 meeting in support of Cycle 5 reload application.

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May 17, 1984

AEP:NRC:0860I

Donald C. Cook Nuclear Plant Unit No. 2
Docket No. 50-316
License No. DPR-74
Cycle 5 Reload

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Denton:

We are transmitting Attachments 1, 2, 3, 4 and 5 in response to a verbal question raised by your consultant, Argonne National Laboratory, during a meeting among the NRC staff, Argonne National Laboratory, Exxon Nuclear Company, and American Electric Power Service Corporation. The meeting was held on March 29, 1984 at your facility. This response is submitted in support of the Donald C. Cook Unit II Cycle 5 reload application.

This document has been prepared following corporate procedures which incorporate a reasonable set of controls to ensure its accuracy and completeness prior to signature by the undersigned.

Very truly yours,

M.P. Alexich MPA 5/17/84
Vice President

bjs

cc: John E. Dolan
W.G. Smith, Jr. - Bridgman
R.C. Callen
G. Charnoff
E.R. Swanson, NRC Resident Inspector - Bridgman

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Attachment 1

Question: How is the inadvertent boron dilution at shutdown while on RHR transient treated, and why is enough time to anticipate the consequences available?

Response: On July 14, 1980 a letter from F. Noon of the Westinghouse Electric Corporation to the Donald C. Cook Nuclear Plant, Plant Manager was received. The identifier for this letter is AEP-80-71. It is identical in content to Attachment 1 of the July 8, 1980 letter from T.M. Anderson of the Westinghouse Electric Corporation to Victor Stello of the NRC. The identifier of Mr. Anderson's letter is NS-TMA-2273. AEP-80-71 is included as Attachment 2.

The Donald C. Cook Nuclear Plant's response to the inadvertent boron dilution at shutdown while on RHR transient is based on AEP-80-71. When one of the Donald C. Cook units is in modes 4, 5 or 6 on RHR, the boron concentration is maintained so that the plant is in the region of "acceptable operation without bank withdrawal" of Figure A-1 of Appendix A to AEP-80-71. This is accomplished by increasing the required boron concentration required by the shutdown margin calculation near the beginning of cycle. The boron concentration required for N-1 rods, no xenon, Unit 2, Cycle 5 is displayed in Attachment 3. It is figure 4.5 of D.C. Cook Unit 2 Plant Technical Data Book. At boron concentrations higher than 640 ppm, the boron concentration required for shutdown is increased above that required for K_{eff} = 0.984. The 68°F curve, which is developed for use below 350°F, is calculated by the method described in Attachment 4. The dilution rate is assumed to be 225 gpm, the value used for the Unit 1 dilution during refueling transient. See Section 14.1.5 of the FSAR. The calculation is done in a conservative manner so as to maximize the boron concentration and hence the time required to dilute to critical. It is also conservative in that typically all rods are inserted in modes 4, 5 or 6 where as the Keff in Attachment 3 is calculated on the assumption that the most reactive rod is sticking out. This results in approximately 1% of additional reactivity to dilute out prior to criticality which is not included in the calculation. Furthermore, the calculation is conservative in that a 100 ppm allowance is added to the shutdown margin curve. This 100 ppm must also be diluted prior to achieving critical. At BOL (C_B approximately 1600 ppm) CZP, half loop when the plant is most vulnerable, 100 ppm amounts to approximately 1.2% of additional reactivity.

The operator has the information available which was assumed in AEP-80-71. These are:

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 clean makeup flow rate,

   b. CVCS valve position status lights, and

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

Procedural guidance for responding to an inadvertent boron dilution incident is contained in the annunciator response for Source Range High Flux at Shutdown and Emergency Boration procedures. These procedures deviate from the recommended Westinghouse response in that our preferred action for a reactivity increase is emergency boration. Use of the "refueling water sequence" is an alternate response. We believe this is appropriate for several reasons:

1. 75 gpm of concentrated boric acid when mixed with 225 gpm of water has a boric acid concentration greater than 2000 ppm.

2. In modes 5 and 6 the "refueling water sequence" may not be available as a boration path.

3. Our operators have repetitively and traditionally been trained to emergency borate for any unexplained or uncontrolled reactivity increase.

To reduce the probability of this transient occurring, certain plant makeup water (PMW) valves are tagged shut prior to draining the primary system to half loop. The valves in question supply the boric acid blender, 2-PW-263, the chemical mixing tank, 2-PW-256, and the PMW flush to the emergency boration line, 2-PW-265. These tags are lifted as part of the valve lineup for filling and venting the primary system. Attachment 5 is a copy of 2-OHP 4021.002.005, "Draining the Reactor Coolant System".

AEP-80-71 indicates that operating the plant in the region of "acceptable operation without bank withdrawal" on Figure A-1 ensures that "the plant operator has fifteen minutes from the initiation of the dilution event to terminate the event before a return to critical occurs". As indicated above, we have applied Figure A-1 with significant conservatism. Therefore, the transient will require 15 minutes or longer to reach criticality in the absence of operator intervention.

ATTACHMENT 2

INDIANA & MICHIGAN ELECTRIC CO.
RECEIVED
JUL 14 1980
DONALD C. COOK PLANT
MANAG[redacted]

Comments Please E

cc: Bert
Ev
Tiny
[redacted]
Dave Nel
Kittle

Westinghouse Electric Corporation

Water Reactor Divisions

Nuclear Service Division

Box 2728
Pittsburgh Pennsylvania 15230

July 9, 1980
AEP-80-3~~4~~ 80-71

RECEIVED
JUL 16 1980
Technical Dept.

Mr. D. V. Shaller, Plant Manager
D. C. Cook Nuclear Plant
Indiana and Michigan Power Company
P. O. Box 458
Bridgman, Michigan 49106

Dear Mr. Shaller:

American Electric Power System
D. C. Cook Units 1 and 2
INADVERTENT BORON DILUTION AT SHUTDOWN WHILE ON RHR

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 not 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 not 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 500 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 intiation 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.

Very truly yours,

D. G. Lokey for

F. Noon, Manager
Eastern Region & WNI Support

SR4/B819/20

cc: R. W. Jurgensen
J. E. Dwyer W

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.

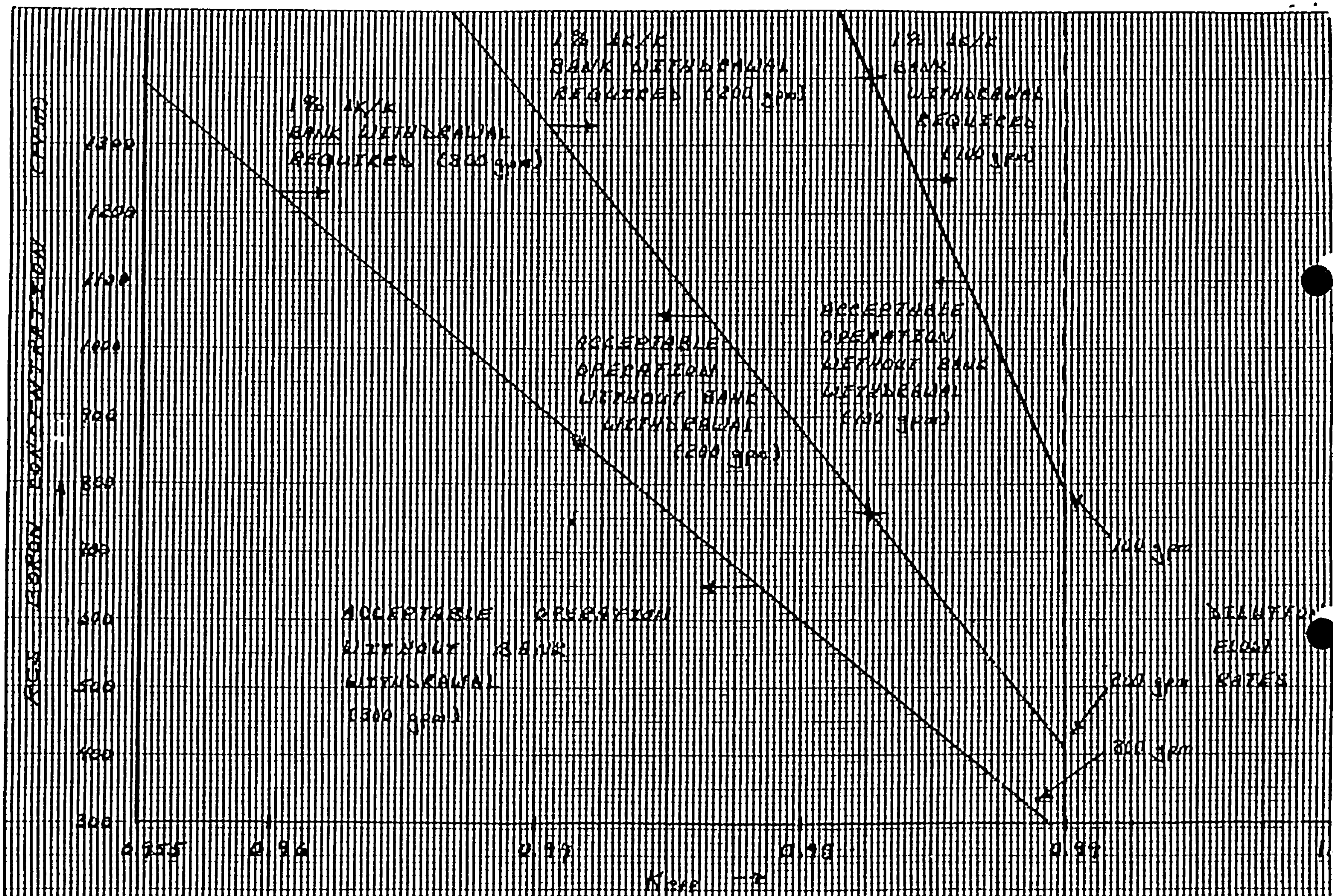
   This is accomplished by valve 8333 for 212 plants, valve 8457 for 312 plants, and valve 8455 for 412 plants.

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.

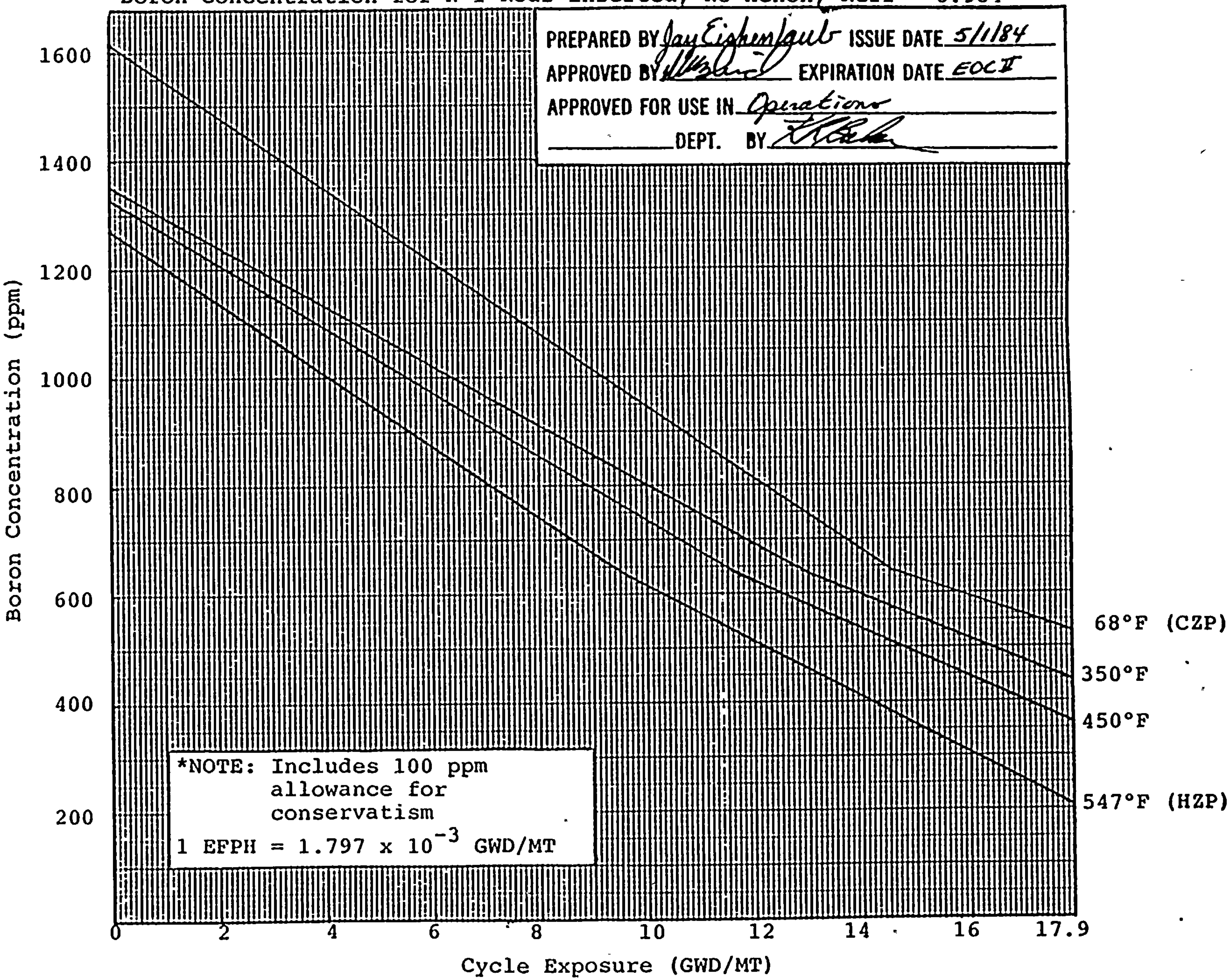
This recommendation precludes the occurrence of an inadvertent dilution while borating or making up water from the RWST under these conditions.



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

FIGURE A-1

2 FIGURE 4.5
D. C. Cook Unit 2 Cycle 5
Boron Concentration for N-1 Rods Inserted, No Xenon, Keff = 0.984



ATTACHMENT 3

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Attachment 4

Shutdown Boron Calculation

Since the boron concentration required to maintain a shutdown margin of 1600 pcm varies with core lifetime, the fuel vendor supplies curves of required boron as a function of core life and moderator temperature. The assumption is made that the most reactive rod is stuck out of the core. Also, 100 ppm in boron concentration is added for conservatism.

The curves supplied by the fuel vendor do not take into account the boron dilution accident. Therefore, the curves are modified as specified in AEP-80-71, Attachment 2, before incorporating the curve in the Plant Technical Data Book. Figure A-1 in AEP-80-71 gives the required Keff, hence the shutdown margin for a given boron concentration. The following procedure is used to recalculate the required shutdown boron.

Step 1 - Interpolate Figure A-1 in Attachment 2 for dilution flow rate of 225 GPM for "all banks in" case.
Note: maximum dilution rate possible is 225 GPM.

Step 2 - Obtain boron concentration S_{B1} from the interpolated line (Step 1) for a Keff of 0.984.
Note: Keff of 0.984 corresponds to a shutdown margin of 1600 pcm.

Step 3 - From the vendor supplied shutdown boron curve for moderator temp of 68°F find the burnup (B_1 MWD/T) corresponding to S_{B1}. Correction to the shutdown boron concentration is not necessary for concentrations less than S_{B1}.

Step 4 - Obtain the shutdown boron S'_{B2} for 0 MWD/T from the vendor supplied curve for moderator temperature of 68°F.

Step 5 - If $S'_{B2} > S_{B1}$, then S'_{B2} needs correction.

Step 6 - Obtain $Keff_2$ corresponding to a boron concentration S'_{B2} from Figure A-1 and calculate $\Delta\rho'$

$$\Delta\rho' = \frac{Keff_2 - 0.984}{Keff_2}$$

Step 7 - Increase $\Delta\rho'$ by an arbitrary factor of 1.4

$$\Delta\rho = 1.4 \times \Delta\rho'$$

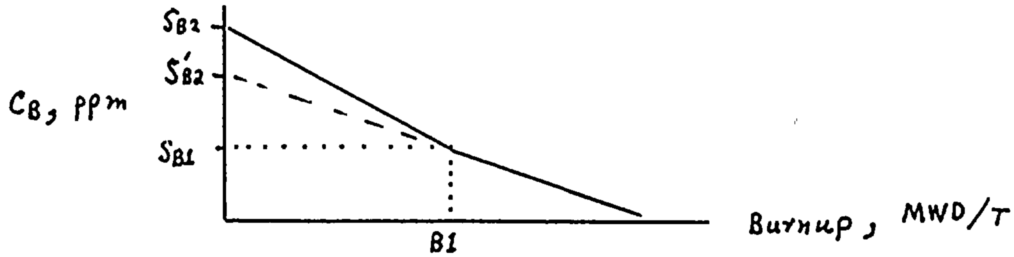
Note: A factor of 1.4 is conservative for the iterative solution required.

Step 8 - Obtain the required shutdown boron concentration

$$S_{B2} = S'_{B2} + \frac{\Delta \rho}{(\partial \rho / \partial C_B)}$$

where $\delta\rho/\delta C_B$ is the boron worth. To conservatively calculate S_{B2}, the boron worth is chosen to be lowest value in the boron concentration and temperature range for which S_{B2} is being calculated.

Step 9 - Draw a straight line between point (SB_2, 0 MWD/T) and point (SB_1, B_1 MWD/T). For burnups higher than B_1 MWD/T, the line specified in the vendor supplied shutdown boron curve is applicable.



Step 10 - Verify that the straight line approximation is conservative.