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A Duke Energy Company

Duke Power Company
McGuire Nuclear Station
Catawba Nuclear Station

Rod Swap Methodology Report
For Startup Physics Testing

DPC-NE-1003-A
Revision 1

SER Dated October 1, 2002

Nuclear Generation Department
Nuclear Engineering

Revision History

Revsion	Description
DPC-NE-1003, Original Issue	Originally submitted to the NRC for approval in October 1986. Additional submittals were made to the NRC supplying additional data and reponses to requests for additional information.
DPC-NE-1003A, Original Issue	NRC approved version issued in May 1987.
DPC-NE-1003, Revision 1	Submitted to the NRC for approval in August 2001. This revsion updates the report for completeness to indicate the use of NRC approved methods approved subsequent to the implementation of the original issue including the use of CASMO-3/SIMLUATE-3 reactor physics methods. This revison also reflects a refinement in the rod swap to make use of two test banks. This revision also reflects the ability of the SIMULATE-3P computer code to iterate numerical results in the determination of the reference bank critical height. Finally, various editorial changes are made, such as reformatting tables and adding a Table of Contents, a List of Tables, and page numbers. Changes associated with this revision are denoted by revision bars, except for the editorial changes mentioned above.
DPC-NE-1003-A Revision 1	NRC approved. SER issued October 1, 2002.

Table of Contents

List of Tables

1. Introduction

This report describes the calculational procedure used to develop the rod swap constants and describes the measurement procedure used to determine the inferred bank worths. This paper also presents a comparison between the calculated and inferred bank worths for McGuire 1 Cycles 2, 3 and 4, and McGuire 2 Cycles 2 and 3.

In order to perform the "Control Rod Worth Measurement - Rod Swap Test Procedure" (2), the following information must be provided to the station. This information shall include the bank worths, critical heights and α's. The critical heights and α's are used to calculate the inferred bank worth of each control and shutdown bank, as reduced from information following the iso-reactivity interchange with the reference bank.

This report presents the calculated procedures used to derive these parameters. The calculations as performed in this procedure utilize the approved physics codes and methodologies described in References 1 and 3.

The rod swap procedure is one of the methods available for determining total rod worth and individual bank worths during zero power physics testing.

2. Definitions

The following is a list of the constants needed by the plant, to perform the rod swap procedure. These include:

- W^P_x - Predicted reactivity worth of each control and shutdown bank, when inserted individually into an otherwise unrodded core.
- h^P_x - Predicted critical position of the reference bank after interchange with bank x, starting with the reference bank at 0 steps and bank x fully withdrawn.
- α_x - A correction factor which accounts for the effect of bank x on the partial integral worth of the reference bank, equal to the ratio of the integral worth of the reference bank from h^P_x to the fully withdrawn position with and without x in the core.

In addition, included is a list of constants and their definitions as used in this report.

- W^I_x - Measured rod bank worth of bank x from rod exchange
- W^m_{Ref} - Measured rod bank worth of reference bank
- $(\Delta\rho_2)_x$ - The measured integral worth of the reference bank from the measured critical position (h^m_x) to the fully withdrawn position.
- h^m_x - The measured critical position of the reference bank after interchange with bank x.
- $(h^m_x)_o$ - The initial critical position of the reference bank before exchange with bank x.
- $(\Delta\rho_1)$ - The measured integral worth of the reference bank from 0 steps to $(h^m_x)_o$.

3. Measurement Procedure

With an initial configuration of all rods out, hot zero power, the integral worth of the reference bank is measured using the standard boration/dilution technique. The reference bank is the bank that is predicted to have the highest integral worth. All other banks are then exchanged with the reference bank or other test banks at constant boron conditions until the measured bank is fully inserted.

The worth of each bank is then the amount of reactivity change caused by the withdrawal of the reference bank to its new critical height.

The rod bank worth is inferred from the measured reference bank worth and the measured reference bank height using the following equation:

$$W^{I}_{X} = W^{M}_{ref} - \alpha_x \ (\Delta\rho_2)_x - (\Delta\rho_1)$$

where the above terms are defined in Section 2.0 of this report.

4. Calculational Procedure

This calculation is performed using EPRI-NODE-P or SIMULATE-3P to model core conditions during the rod swap procedure. The following procedure describes the method of data generation:

1. Calculate the integral bank worth at HZP, ARO critical boron. Insert one bank at a time with no overlap and calculate the bank worth as the difference between ARO and the bank fully inserted condition. (The calculated highest worth bank will be considered the reference bank.)

2. With the reference bank fully inserted, calculate the critical boron concentration. (The reference bank in boron concentration is used in predicting the predicted rod worth - W^P_x).

3. Using the above calculated critical boron concentration for the reference bank, the new integral bank worths at HZP are determined. These values correspond to the predicted worth for each bank (W^P_x).

   The reference bank should be inserted in approximately six (6) step increments such that a plot of the integral worth of the reference bank can be obtained. (As should be noted, the K_{eff} with the reference bank inserted, is referred to as the base K_{eff}).

4. In order to calculate the critical height, the core is modeled with the measured bank fully inserted. The critical height (h^P_x) of the reference bank is then determined by adjusting the reference bank position until the K_{eff} matches the base K_{eff}.

5. In order to calculate α for each bank position, the following expression is used:

$$\alpha = \frac{\text{Integral Worth of the reference bank from } h^P_x \text{ to the fully withdrawn position \underline{with} bank x inserted in the core}}{\text{Integral worth of the reference bank from } h^P_x \text{ to the fully withdrawn position \underline{without} bank x inserted in the core}}$$

5. Results

Tables 1 and 2 present a comparison between Duke's predicted and inferred bank worths. A review of the available data from McGuire 1 Cycles 2, 3, and 4, and McGuire 2 Cycles 2 and 3, identifies a mean difference of 5.27 pcm or 0.66% between Duke's predicted and inferred bank worths.

Tables 3 and 4 identify a comparison between measured and predicted total critical heights. The standard deviation of the differences between the measured critical heights and Duke's calculated critical heights is 12.63.

Table 5 presents some typical α values as calculated for McGuire 1, Cycle 3.

Additional benchmarking of predicted and measured rod worth data using SIMULATE-3P can be found in Section 3.2 of Reference 3.

6. <u>Conclusion</u>

Reference to the Rod Swap Test Procedure (2) identifies the specific acceptance criteria. In order to satisfy this procedure the following conditions must be met:

(a) The absolute value of the percent difference between the measured and predicted integral worth for the reference bank is $\leq$ 15%.

(b) The sum of the measured/inferred worth of all the rods must be > 90% of the predicted rod worth.

(c) For all RCC banks other than the reference bank, either:

(i) the percent difference between the inferred and predicted worth for each individual bank is $\leq$ 30%

<u>or</u>

(ii) $|W^I_x - W^P_x| \leq 200$ pcm for each bank,

whichever is greater.

These criteria were found acceptable using Duke's predicted values.

Based on the predicted and measured data presented in this report the rod swap method described has been verified to be accurate for use in startup physics testing.

Table 1

Duke Predicted and Inferred Bank Worth

Unit/Cycle	Bank	Duke Predicted Worth (PCM)	Duke Inferred Worth (PCM)	Difference (PCM)	Difference (%)
1/2	CA	289	301	-12	-4.0
	CB	557	606	-49	-8.1
	CC	786	788	-2	0.3
	CD	616	566	50	8.8
	SA	473	546	-73	-13.4
	SB	443	479	-36	-7.5
	SC	370	354	16	4.5
	SD	362	374	-12	-3.2
	SE	223	237	-14	-5.9
Total		4119	4251	-132	-3.1
Mean		-	-	-14.67	-3.17
Standard Deviation		-	-	35.94	6.80

Difference (PCM) = Predicted - Inferred

$$\text{Difference (\%)} = \frac{W^P - W^I}{W^I} \times 100$$

Table 1 (Cont.)

Duke Predicted and Inferred Bank Worth

Unit/Cycle	Bank	Duke Predicted Worth (PCM)	Duke Inferred Worth (PCM)	Difference (PCM)	Difference (%)
1/3	CA	311	305	6	2.0
	CB	657	609	48	7.9
	CC	789	745	44	5.9
	CD	488	466	22	4.7
	SA	269	303	-34	-11.2
	SB	856	779	77	9.9
	SC	394	373	21	5.6
	SD	395	383	12	3.1
	SE	429	392	37	9.4
Total		4588	4355	233	5.4
Mean		-	-	25.89	4.14
Standard Deviation		-	-	31.16	6.34

Difference (PCM) = Predicted - Inferred

$$\text{Difference (\%)} = \frac{W^P - W^I}{W^I} \times 100$$

Table 1 (Cont.)

Duke Predicted and Inferred Bank Worth

Unit/Cycle	Bank	Duke Predicted Worth (PCM)	Duke Inferred Worth (PCM)	Difference (PCM)	Difference (%)
1/4	CA	301	313	-12	-3.8
	CB	656	677	-21	-3.1
	CC	775	778	-3	-0.4
	CD	581	556	25	4.5
	SA	293	307	-14	-4.6
	SB	746	750	-4	-0.5
	SC	381	377	4	1.1
	SD	382	314	68	21.7
	SE	473	471	2	0.4
Total		4588	4543	45	1.0
Mean		-	-	5	1.7
Standard Deviation		-	-	27.04	8.0

Difference (PCM) = Predicted - Inferred

$$\text{Difference (\%)} = \frac{W^P - W^I}{W^I} \times 100$$

Table 1 (Cont.)

Duke Predicted and Inferred Bank Worth

Unit/Cycle	Bank	Duke Predicted Worth (PCM)	Duke Inferred Worth (PCM)	Difference (PCM)	Difference (%)
2/2	CA	437	459	-22	-4.8
	CB	413	452	-39	-8.6
	CC	858	871	-13	-1.5
	CD	654	664	-10	-1.5
	SA	327	430	-103	-24.0
	SB	425	480	-55	-11.5
	SC	354	375	-21	-5.6
	SD	355	374	-19	-5.1
	SE	270	292	-22	-7.5
Total		4093	4397	-304	-6.9
Mean		-	-	-33.78	-7.79
Standard Deviation		-	-	29.42	6.87

Difference (PCM) = Predicted - Inferred

$$\text{Difference (\%)} = \frac{W^P - W^I}{W^I} \times 100$$

Table 1 (Cont.)

Duke Predicted and Inferred Bank Worth

Unit/Cycle	Bank	Duke Predicted Worth (PCM)	Duke Inferred Worth (PCM)	Difference (PCM)	Difference (%)
2/3	CA	344	314	30	9.6
	CB	698	668	30	4.5
***	CC	869	787	82	10.4
	CD	591	530	61	11.5
	SA	381	404	-23	-5.7
	SB	906	842	64	7.6
	SC	438	378	60	15.9
	SD	440	406	34	8.4
	SE	481	424	57	13.4
Total		5148	4753	395	8.3
Mean		-	-	43.89	8.40
Standard Deviation		-	-	30.70	6.23

*** This was the reference bank used because vendor supplied data was used for the official rod swap calculation.

Difference (PCM) = Predicted - Inferred

$$\text{Difference (\%)} = \frac{W^P - W^I}{W^I} \times 100$$

Table 2

Summary of Duke Predicted and Inferred Bank Worth

	Duke Calculated	
	Difference (PCM)	Difference (%)
Mean	5.27	.66
Standard Deviation	40.72	8.69

Difference (PCM) = Predicted - Inferred

$$\text{Difference } (\%) = \frac{W^P - W^I}{W^I} \times 100$$

Table 3

Duke Predicted and Measured Critical Heights

Unit/Cycle	Bank	Critical Height (Steps) Measured	Critical Height (Steps) Predicted	Difference (Steps)
1/2	CA	83	88	-5
	CB	197	195	2
	CD	183	196	-13
	SA	191	187	4
	SB	156	157	-1
	SC	144	158	-14
	SD	147	156	-9
	SE	86	92	-6
Σ		-	-	-42
Σ of Absolute Value		-	-	54
Standard Deviation		-	-	6.63

Difference (Steps) = Measured - Predicted

Table 3 (Cont.)

Duke Predicted and Measured Critical Heights

Unit/Cycle	Bank	Critical Height (Steps) Measured	Predicted	Difference (Steps)
1/3	CA	127	117	10
	CB	180	172	8
	CC	224	201	23
	CD	163	156	7
	SA	127	111	16
	SC	139	133	6
	SD	141	133	8
	SE	132	126	6
Σ		-	-	84
Σ of Absolute Value		-	-	84
Standard Deviation		-	-	6.00

Difference (Steps) = Measured - Predicted

Table 3 (Cont.)

Duke Predicted and Measured Critical Heights

Unit/Cycle	Bank	Critical Height (Steps) Measured	Predicted	Difference (Steps)
1/4	CA	108	121	-13
	CB	201	203	-2
	CD	179	191	-12
	SA	136	149	-13
	SB	218	216	2
	SC	147	161	-14
	SD	136	161	-25
	SE	151	163	-12
Σ		-	-	-89
Σ of Absolute Value		-	-	93
Standard Deviation		-	-	8.15

Difference (Steps) = Measured - Predicted

Table 3 (Cont.)

Duke Predicted and Measured Critical Heights

Unit/Cycle	Bank	Critical Height (Steps) Measured	Predicted	Difference (Steps)
2/2	CA	153	146	7
	CB	190	191	-1
	CD	202	205	-3
	SA	198	186	12
	SB	194	183	11
	SC	185	182	3
	SD	184	182	2
	SE	149	141	8
Σ		-	-	39
Σ of Absolute Value		-	-	47
Standard Deviation		-	-	5.49

Difference (Steps) = Measured - Predicted

Table 3 (Cont.)

Duke Predicted and Measured Critical Heights

Unit/Cycle	Bank	Critical Height (Steps) Measured	Predicted	Difference (Steps)
2/3	CA	99	112	-13
	CB	173	191	-18
	CD	158	179	-21
	SA	123	145	-22
	SB	228	228	0
	SC	130	159	-29
	SD	131	159	-28
	SE	131	147	-16
Σ		-	-	-147
Σ of Absolute Value		-	-	147
Standard Deviation		-	-	9.24

Difference (Steps) = Measured - Predicted

Table 4

Summary of Duke Predicted and Measured Critical Heights

	Duke Calculated
Σ (Differences)	-155
Σ (Absolute Value of Differences)	425
Standard Deviation (of the Differences)	12.63

Difference (Steps) = Measured - Predicted

Table 5

α Factors

Unit/Cycle	Bank	Calculated
1/3	CA	1.042
	CB	0.877
	CC	0.870
	CD	1.161
	SA	1.060
	SC	1.052
	SD	1.050
	SE	0.903

7. References

1. Duke Power Company, "Nuclear Physics Methodology for Reload Design", DPC-NF-2010A, June 1985.

2. Duke Power Company, McGuire Nuclear Station, "Control Rod Worth Measurement: Rod Swap Test Procedure", PT/0/A/4150/11A, April 1984.

3. Duke Power Company, "Nuclear Design Methodology Using CASMO-3/SIMULATE-3P", DPC-NE-1004A, Revision 1, SER Dated April 26, 1997.

APPENDIX A

NRC/DPC Correspondence Including DPC Responses

to NRC Requests for Additional Information

DUKE POWER COMPANY
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CHARLOTTE, N.C. 28242

HAL B TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

February 11, 1987

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: McGuire Nuclear Station
Docket Nos. 50-369/370
Catawba Nuclear Station
Docket Nos. 50-413/414
Determination of Rod Worth Using
Rod Swap Methodology

Gentlemen:

By letter dated December 4, 1986, Duke submitted for information to NRC a description of the method by which bank worths are determined in startup physics testing. By letter of January 12, 1987, the Staff responded to the submittal with a request for additional information. Attached are the responses to the Staff's questions.

It is intended that the methodology described in the December 4, 1986 submittal will be used for the next reloads of Duke's Westinghouse plants; the first of which is scheduled for May 1, 1987.

Very truly yours,

Hal B. Tucker

SAG/54/jgm

Attachment

xc: Mr. Darl Hood, Project Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dr. J. Nelson Grace, Regional Administrator
U.S. Nuclear Regulatory Commission - Region II
101 Marietta Street NW - Suite 2900
Atlanta, GA 30323

Mr. W.T. Orders
NRC Resident Inspector
McGuire Nuclear Station

bxc: <u>w/o attachment</u>
R.H. Clark
M.S. Kitlan
E.O. McCraw
R. Van Namen
N.A. Rutherford
R.L. Gill
MC-801.02
(7)

ATTACHMENT

QUESTION 1: Are all the rod worth calculations done with the EPRI-NODE-P Code, including both rod swap and rod worth for shutdown margin?

RESPONSE: Shutdown Margin calculations are performed according to the methodology approved in DPC-NF-2010A. Rod worths for both the shutdown margin calculation and the rod swap calculations are done using EPRI-NODE-P.

NOTE: See Section 5.4 of DPC-NF-2010A for the procedure for shutdown margin calculations.

QUESTION 2: Section 3, "Measurement Procedure": submit detailed procedures for the measurements. Include the actual boron dilution rate and the flux level for each of the tests included in the report.

RESPONSE: The most current procedures used in the rod swap measurements are enclosed as Attachments 1, 2, and 3.

A summary of the reactivity insertion rates and flux levels for each of the tests in the reference is presented below. Flux levels are values as measured on the reactivity computer picoammeter.

UNIT/CYCLE	REACTIVITY INSERTION RATE (PCM/HR)	TEST RANGE (AMPS)	POINT OF ADDING NUCLEAR HEAT (AMPS)
M1C2	450	1 E-8 TO 1 E-7	1.4 E-6
M1C3	460	1 E-8 TO 1 E-7	4.25 E-7
M1C4	420	1 E-8 TO 1 E-7	5.1 E-7
M2C2	480	1 E-7 TO 1 E-6	1.6 E-6
M2C3	720	1 E-7 TO 1 E-6	1.65 E-6

QUESTION 3: Section 4, "Calculational Procedure" - under 5: How many calculations are performed for each bank and at what positions.

RESPONSE: One α is calculated for each bank (except for the reference bank) at the predicted critical height. These calculations use the results of cases performed for Sections 4.3 and 4.4 of the reference. Cases are done with the reference bank being inserted in approximately 6-step increments both by itself and in the presence of the bank being predicted.

QUESTION 4: Table 3, "∝'s": Are the values given at the predicted heights?

RESPONSE: Alpha (∝) is the ratio of the reference bank worth from the predicted critical height to out of the core with and without bank X in the core. Values for are given at the predicted critical heights. However, the ratio of the reference bank worth with and without bank X in the core is insensitive to variations in the predicted critical heights and will have no significant impact on the inferred worth.

QUESTION 5: Submit a copy of Reference 2.

RESPONSE: Reference 2: Duke Power Company McGuire Nuclear Station, "Control Rod Worth Measurement: Rod Swap Test Procedure," PT/O/A/4150/11A, April, 1984 test procedure is enclosed as Attachment 4.

QUESTION 6: Provide data for at least 2 sets of side-by-side comparisons of boron dilution and rod swap data - predicted and measured. The data may be either for your plants or measured data from another plant and predictions by Duke.

RESPONSE: Table with requested data is provided below. All rod worths are given in units of PCM.

UNIT/ CYCLE	BANK	PREDICTED WORTH	BOR/DILUTION MEAS WORTH	% DIFF ((P-M)/M)*100)	ROD SWAP INF WORTH	% DIFF ((P-I)/I)*100
M1C2	CD	616	566	8.8	586	5.1
M1C3	CD	488	483	1.0	466	4.7
M1C4	CD	581	580	0.2	556	4.5
M2C2	CD	654	665	-1.7	664	-1.5
M2C3	CD	591	556	6.3	530	11.5
MEAN				2.9		4.9
STANDARD DEVIATION				4.4		4.6

<u>QUESTION 7</u>: What Organization does the safety analysis for the Duke Plants? When this is not done by Duke, what is done (e.g. tests, comparisons, etc.) to show that the startup test results adequately represent the plant features and assumptions used in the safety analyses?

<u>RESPONSE</u>: Cycle specific safety reviews and any safety re-analyses required for McGuire and Catawba are performed by Westinghouse, the current fuel vendor. Assuming all startup tests meet acceptance criteria, transmittal of the results to Westinghouse is formally accomplished by providing them a copy of the startup report prepared for the NRC. If any review or acceptance criteria are exceeded, the the action statements in the procedure are followed. Actions required usually include review of the test data and predicted values, assessment of impacts on safety analyses and technical specification limits, etc. Groups involved in these reviews include the Site Reactor Group, the General Office Nuclear Design Group and, as necessary, Site Compliance, G.O. Licensing, G.O. Safety Analysis, and Westinghouse.

The main safety analysis assumption verified by the rod swap procedure is that the plant will maintain adequate shutdown margin per technical specifications. One of the purposes of rod swap measurements and comparisons is to verify the accuracy of the total rod worth prediction used as an input to the shutdown margin calculation. An independent Duke Power shutdown margin is evaluated for each cycle using methods approved by the NRC in DPC-NF-2010A. The N-1 rod worth used in this prediction is reduced by 10% for conservatism. Acceptance criteria listed in the procedure indicate that the total inferred rod worth as measured in the rod swap testing must be within 10% of the total predicted worth. If the total measured rod worth is less than the predicted worth by more than 10%, a review of the shutdown margin is made to determine if the current rod insertion limits provide adequate shutdown margin. If the shutdown margin is adequate, then no revision of the limits is necessary. However, if the margin is not maintained, then Duke will notify Westinghouse, revise the rod insertion limits, and submit any necessary changes in the technical specifications to the NRC.

<u>Reference</u>

McGuire Nuclear Station, Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testing, DPC-NE-1003, Rev. 1, December 1986.

QUESTION 2

Attachment 1

Form 34731 (R9-86)

(1) ID No. PT/0/A/4150/21

Change(s) 0 to 31 Incorporated

FOR INFORMATION

PREPARATION

(2) STATION McGUIRE

(3) PROCEDURE TITLE POST REFUELING CONTROLLING PROCEDURE FOR CRITICALITY, ZERO POWER PHYSICS, AND POWER ESCALATION TESTING

(4) PREPARED BY Carlos W. Roberson DATE 1/6/87

(5) REVIEWED BY M. Todd Keller DATE 1/6/87

Cross-Disciplinary Review By ______ N/R MTK

(6) TEMPORARY APPROVAL (If Necessary)

By ______ (SRO) DATE ______

By ______ DATE ______

(7) APPROVED BY Bruce Hamilton DATE 1/7/87

(8) MISCELLANEOUS

Reviewed/Approved By ______ DATE ______

Reviewed/Approved By ______ DATE ______

(9) COMMENTS (For procedure reissue indicate whether additional changes, other than previously approved changes, are included. Attach additional pages, if necessary.) ADDITIONAL CHANGES INCLUDED. ☐ Yes ☒ No

(10) COMPARED WITH CONTROL COPY TW Miraglia DATE 1/29/87

COMPLETION

(11) DATE(S) PERFORMED ______

(12) PROCEDURE COMPLETION VERIFICATION

☐ Yes ☐ N/A Check lists and/or blanks properly initialed, signed, dated or filled in N/A or N/R, as appropriate?

☐ Yes ☐ N/A Listed enclosures attached?

☐ Yes ☐ N/A Data sheets attached, completed, dated and signed?

☐ Yes ☐ N/A Charts, graphs, etc. attached and properly dated, identified and marked?

☐ Yes ☐ N/A Acceptance criteria met?

VERIFIED BY ______ DATE ______

(13) PROCEDURE COMPLETION APPROVED ______ DATE ______

(14) REMARKS (Attach additional pages, if necessary.)

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
POST REFUELING CONTROLLING PROCEDURE FOR CRITICALITY, ZERO POWER PHYSICS, AND POWER ESCALATION TESTING

1.0 Purpose

1.1 To provide a sequence of tests for the orderly startup of the unit after refueling.

1.2 To perform nuclear instrumentation overlap verification.

1.3 To determine the point of nuclear heat.

1.4 To establish the neutron flux levels corresponding to the Zero Power Physics Test Band.

1.5 To perform a checkout of the reactivity computer.

2.0 References

2.1 McGuire Nuclear Station Technical Specifications

2.2 WCAP-9648, Post-Refueling Nuclear Testing Program Criticality to Full Power.

2.3 The appropriate unit and cycle Nuclear Design Report.

3.0 Time Required

5 days, 2 engineers per shift - 3 shifts

4.0 Prerequisite Tests

Initial/Date

____/____ 4.1 PT/0/A/4600/14B, NIS Intermediate Range Calibration Functional Test (see Step 7.4).

____/____ 4.2 PT/0/A/4600/14A, NIS Power Range Calibration Functional Test (see Step 7.5)

NOTE: The tests in 4.1 and 4.2 must be completed within 12 hours prior to beginning Physics Testing. Physics testing is defined as beginning when Control Rods are being withdrawn to achieve criticality. This occurs in Step 12.9 of PT/0/A/4150/28, Criticality Following a Change in Core Nuclear Characteristics.

5.0 Test Equipment

5.1 Reactivity Computer connected to one power range detector (Enclosure 13.6) (See Step 8.2 for installation step.)

5.2 Chart recorders to display reactivity, flux, pressurizer level, and T_{avg}.

5.3 Stopwatch or timer

5.4 Communications between Control Room operators and testing work station.

6.0 Limits and Precautions

6.1 The startup rate is administratively limited to 0.5 DPM.

6.2 During the Zero Power Physics Tests (Steps 12.3 - 12.10.20) Special Test Exception 3.10.3 will be invoked. The appropriate Surveillance Requirements will be monitored by Operations.

6.3 Notify Westinghouse if any incore tilts exceed 2%.

6.4 The primary indication of core power will be ΔT, which should be cross checked with the NIS and the Thermal Power calculation on the OAC. If the thermal power and Power Range NIS disagree by more than 2%, then adjustment is necessary per Tech Spec 3/4.3.1, Table 4.3-1, notation 2. (IP/0/A/3007/17)

6.5 If the excore power indications are conservative, use caution when increasing power to avoid the high level trip setpoints.

6.6 Observe the Fuel Maneuvering Limits as outlined in Data Book Section 1.3.

7.0 Required Unit Status

Initial/Date

____/____ 7.1 The unit is in Mode 3 - Hot Standby

____/____ 7.2 The points listed on Enclosure 13.1 are being logged on OAC Gen. 24 program once per 6 minutes printed every 8 hours.

____/____ 7.3 Record the unit and cycle to which this procedure is being applied, in the test log.

8.0 Prerequisite System Conditions

____/____ 8.1 All RCC control banks and shutdown banks are fully inserted.

____/____ 8.2 Begin to install the reactivity computer per Enclosure 13.6. The reactivity computer shall be installed before beginning Step 12.4.

____/____ 8.3 An evaluation of the impact of the core alterations on the excore detector sensitivity has been made. Document the results in the test log. Attach to this procedure any correspondence from offsite personnel on this subject.

____/____ 8.4 Perform Enclosure 13.10 to demonstrate adequate Shutdown Margin at the zero power insertion limits per Tech Spec 4.1.1.1.1d.

____/____ 8.5 Perform Enclosure 13.9 to verify adequate Shutdown Margin during Rod Swap.

____/____ 8.6 Provide I&E 7300 Systems Engineer with the new cycle 100% F.P. predicted value of Reactor Vessel Tave.

____/____ 8.7 I&E 7300 Systems Engineers have set ΔT values to conservative numbers as necessary in the protection cabinets. Record in the test log the values which have been set in the cabinets.

9.0 Test Method

The reactor is brought critical with the procedure for criticality. Then, the Intermediate Range (I/R) NIS overlap data is recorded, the point-of-nuclear-heat flux level determined, and the Zero Power Physics Test (ZPPT) band is established. Also, the reactivity computer is verified to be set up correctly by making reactivity changes and comparing the computer response to the calculated reactor period.

Next, the ZPPT's are performed to measure the ARO boron concentration, control rod worths, moderator temperature coefficients, and the low-power core power distribution (if necessary).

Finally, power escalation is begun, with a full core flux map between 10% and 50% full power. During the escalation above 50% full power, data is taken for the Power Range NIS calibrations. At ~80% full power, the P/R NIS is calibrated, then power is increased 100% full power. At 100% full power, the core power distribution, the NIS calibration, the thermal power output program, and the reactivity anomolies are all checked. Also, the target flux difference is measured, and Reactor Coolant System Flow Test is performed.

10.0 Data Required

10.1 Nuclear instrumentation overlap will be recorded on Enclosure 13.2.

10.2 The point of nuclear heat will be recorded on Enclosure 13.3.

10.3 The reactivity computer checkout results will be recorded on Enclosure 13.4.

10.4 Output of OAC Gen. 24 program per Enclosure 13.1.

10.5 Intermediate range high level trip setpoints on Enclosure 13.7.

10.6 Verification of adequate Shutdown Margin at the zero power insertion limits on Enclosure 13.10.

10.7 Verification of Shutdown Margin during Rod Swap on Enclosure 13.9.

11.0 Acceptance Criteria

11.1 There is at least one decade overlap on the NIS between the Source and Intermediate Ranges, and between the Intermediate and Power Ranges (NOTE: Power Ranges are calibrated to Thermal Power, Best Est. (P1385). Use P1385 for Power Range overlap data).

11.2 The value of the reactivity measured by the reactivity computer is within .04 (4%) or 1 PCM, whichever is greater, of the reactivity inferred from the reactor period, or doubling time.

$$\left|\frac{\Delta\rho_c - \Delta\rho_{DT}}{\Delta\rho_{DT}}\right| \leq .04\ (4\%) \text{ or } 1 \text{ pcm}$$

11.3 All acceptance criteria in each test procedure for the tests contained in this controlling procedure have been met.

12.0 Procedure

Initial/Date

____/____ 12.1 Attach as Page 2 of Enclosure 13.4 the table of "reactivity and doubling time as a function of stable reactor period at BOL, HZP conditions" for the appropriate unit and cycle. Also attach as Page 3 of Enclosure 13.4 the curve (if provided) "Reactor Period and Doubling Time as a Function of Reactivity at BOL, HZP, No Xenon" for the appropriate unit and cycle.

____/____ 12.2 Inform the Operations Shift Supervisor that Special Test Exception Tech Spec 3.10.3 will be entered during criticality and Zero Power Physics Testing (Steps 12.3 - 12.10). Operations shall monitor the appropriate Surveillance Requirements during these Steps.

____/____ 12.3 Complete PT/0/A/4150/28, Criticality Following a Change in Core Nuclear Characteristics. It is permissible to sign off this step prior to signing off Steps 12.18 and 12.19 in PT/0/A/4150/28.

<u>NOTE</u>: Section 7.0 of this procedure will have been completed earlier.

<u>NOTE</u>: See Step 4.1 and 4.2.

____/____ 12.4 Begin PT/0/B/4600/55, Reactivity Computer Periodic Test approximately 4-6 hours prior to Step 12.6.

____/____ 12.5 Record the IR high level trip setpoints on Enclosure 13.7.

____/____ 12.6 With a Source Range reading of $\cong 10^3$ cps and the reactor just critical withdraw Control Bank D or add demineralized water, to establish a slow positive startup rate (<50 pcm). When the Intermediate Range indication comes on scale, halt the flux level increase, establish just critical conditions, and record data as required by Enclosure 13.2, Page 1 of 2.

____/____ 12.7 Continue to increase the flux level, stopping, establishing just critical conditions, and recording data with each decade increase in the Intermediate Range until the Source Range is blocked.

<u>CAUTION</u>: Do not exceed 10^5 cps on the Source Range unless the Source Range is blocked, as a reactor trip will occur.

CAUTION: I/R high level trip setpoints are on Enclosure 13.7; do not exceed these values.

___/___ 12.7.1 Verify from Enclosure 13.2 Page 1 of 2 that a minimum of one full decade of overlap exists between the Source Range and Intermediate Range before the Source Range reaches 10^5 cps.

12.8 Determine the flux level at which the point of nuclear heat occurs by the following steps.

___/___ 12.8.1 Set up 1, 2 pen strip chart recorder with T_{avg} and reactivity, another 2 pen strip chart recorder with pressurizer level and flux signal.

___/___ 12.8.2 Establish just critical conditions with reactivity computer picoammeter reading of about 1×10^{-8} amps. Adjust the scale setting on the reactivity computer picoammeter (if necessary) such that the indicator is on scale and indicating a value near the low end of the scale. Record start values on Enclosure 13.3.

NOTE: Stop increase if nuclear heat is observed prior to reaching this level, and repeat Step 12.5.2 from 1×10^{-9} amps on the reactivity computer picoammeter.

___/___ 12.8.3 Establish a slow positive startup rate by rod withdrawal of about 20 pcm and allow the flux level to increase until nuclear heat is observed. At this time, re-establish just critical conditions by Control Bank D adjustment. Record Nuclear Heat Data on Enclosure 13.3.

NOTE: Nuclear heat can be best observed as an increase T_{avg} accompanied by a change in the reactivity trace and an increase in pressurizer level.

NOTE: It is permissible to also trend pressurizer level, Intermediate Range Level, and NC Loop Highest Average Temperature on the OAC to aid in the determination of nuclear heat.

___/___ 12.8.4 Repeat Steps 12.8.2 and 12.8.3 a second time and record all data as requested on Enclosure 13.3.

___/___ 12.8.5 Determine the Zero Power Physics Testing Range from the reactivity computer picoammeter flux levels on Enclosure 13.3. Record on Enclosure 13.3.

NOTE: The range for all Zero Power Physics Testing will be defined as the next lowest whole decade such that the upper end of the decade is not within $\sqrt{10}$ of nuclear heat.

EXAMPLE: If nuclear heat is found at 5×10^{-6} amps on the picoammeter then

$$\frac{5 \times 10^{-6}}{\sqrt{10}} = 1.5 \times 10^{-6} \text{ and}$$

the range for zero power testing is 1.0×10^{-7} to 1.0×10^{-6} amps.

NOTE: If the signal is not clear for the decade defined, evaluate the situation and if changes are needed to be made to the testing decade, fully document in the test log the reason for the change before continuing.

___/___ 12.8.6 Insert Control Bank D slightly, allow the flux to decrease until the reactivity computer picoammeter reads near the low end within the Zero Power Physics Test range determined above, and level out again.

12.9 Perform a checkout of the reactivity computer.

___/___ 12.9.1 Withdraw Control Bank D until a reactivity gain of approximately +25 pcm is indicated by the reactivity computer.

___/___ 12.9.2 Let the flux increase to a stable period and measure the doubling time at two or three different times over the decade using a stopwatch or timer. From the doubling time, calculate the period from the following equation and record on Enclosure 13.4, page 1:

$$\text{period} = \frac{DT}{0.693}$$

___/___ 12.9.3 Using the table on Page 2 of Enclosure 13.4, or the curve (if provided) on Page 3 of Enclosure 13.4, convert the observed period to reactivity and record on page 1 of Enclosure 13.4.

___/___ 12.9.4 Record all data on Enclosure 13.4.

___/___ 12.9.5 Repeat measurement as needed until at least three checks have been performed.

___/___ 12.9.6 Repeat Steps 12.9.1 through 12.9.4 for a reactivity addition of +50 pcm.

___/___ 12.9.7 Repeat measurement as needed until at least three checks have been performed.

___/___ 12.9.8 Verify the Acceptance Criteria of 11.2 has been met for the positive reactivity insertions only.

___/___ 12.9.9 Verify a negative reactivity insertion check has been performed satisfactorily on the reactivity computer per PT/0/B/4600/55, Reactivity Computer Periodic Test.

___/___ 12.9.10 Position Control Bank D at ≅220 steps by boration or dilution.

___/___ 12.10 Zero Power Physics Testing

Complete the tests listed below. Normal operating procedures shall be used to reconfigure the plant to meet any prerequisites. All tests should be performed within the test band established in Step 12.8.5, except power will be increased up to ≅3-4% full power for the low power flux map if it is taken.

___/___ 12.10.1 Perform PT/0/A/4150/10, Boron Endpoint Measurement.

___/___ 12.10.2 Perform PT/0/A/4150/12, Isothermal Temperature Coefficient Measurement for the ARO case.

___/___ 12.10.3 Perform PT/0/A/4150/31, Determination of Rod Withdrawal Limits to Ensure Moderator Temperatures Within Limits of Technical Specifications. Testing may continue under Special Test Exception Tech Spec 3.10.3; however, PT/0/A/4150/31 Section 12.1 must be performed prior to the completion of data gathering for the Rod Swap test of Step 12.10.5. If the MTC calculated in Step 12.10.2 is less than 0 pcm/°F, mark this step N/A.

___/___ 12.10.4 Record on Enclosure 13.8 the Reference Bank, rod banks, and sequence to be measured by rod swap.

<u>NOTE</u>: If the predicted worth of any bank is close to the predicted worth of the reference bank, measure this bank last.

___/___ 12.10.5 Perform PT/0/A/4150/11A, Control Rod Worth Measurement - Rod Swap. This measurement is to be done for the rod banks identified on Enclosure 13.8.

___/___ 12.10.6 Following Rod Swap Measurements swap Control Bank D with the reference bank until Bank D is fully inserted.

___/___ 12.10.7 If Section 12.1 of PT/0/A/4150/31, Determination of Rod Withdrawal Limits procedure indicates no rod withdrawal limits are needed mark Step 12.10.8, 12.10.9, and 12.10.11 as N/A and continue. If the indication is that rod withdrawal limits will be needed, perform Steps 12.10.8, 12.10.9 and 12.10.11.

<u>NOTE</u>: It is permissible to perform Steps 12.10.8 and 12.10.9 if desired even though it might not be required. In that case, N/A Step 12.10.11.

___/___ 12.10.8 Place the rods close to a D-in only configuration by borating the reference bank out.

___/___ 12.10.9 Perform PT/0/A/4150/12 Isothermal Temperature Coefficient Measurement for the D-in case.

___/___ 12.10.10 Perform PT/0/A/4150/11 Control Rod Worth Measurement. This measurement is to be done only for Control D as it is completely withdrawn by boration.

____/____ 12.10.11 Perform Section 12.2 of PT/0/A/4150/31, Determintaion of Rod Withdrawal Limits to Ensure Moderator Temperature Coefficient within Limits of Technical Specifications.

____/____ 12.10.12 Perform the following steps to reset bank overlap once Control Bank D is about 215 steps withdrawn.

____/____ 12.10.12.1 Go to the Master Cycler Cabinet and reset the Bank Overlap Digital Counter to 000 by pushing the reset button.

____/____ 12.10.12.2 Reset the Bank Overlap Counter to 345 plus the present Control Bank D position by pushing the button to count up from 000 to the desired value (one push of the button is one digit change on the display).

NOTE: Perform Steps 12.10.13 and 12.10.14 in any order or concurrently.

____/____ 12.10.13 Increase reactor power by dilution or Control D withdrawal so that both approximately 3-4% full power and Control D about 215 steps withdrawn are achieved.

NOTE: Control D may be placed in a configuration for power increase if Step 12.10.17 is to be marked N/A.

____/____ 12.10.14 Remove reactivity computer from the Power Range NIS Channel to which it is connected and return the Channel to OPERABLE status using Enclosure 13.6.

____/____ 12.10.15 Verify that Thermal Power, Best Est. reasonably agrees with the indicated loop ΔT's. Resolve any problems.

NOTE: Thermal Power should be approximately: [(loop avg ΔT(°F) $\cdot$ ($\frac{75\%}{45°F}$)], between 0-75% full power.

____/____ 12.10.16 Verify all power range channels are operable.

CAUTION: Do not continue until Step 12.10.16 is completed.

____/____ 12.10.17 Perform PT/0/A/4150/02A, Core Power Distribution if any rod swap acceptance criteria were not met in PT/0/A/4150/11A. Mark N/A here and also Step 12.10.19 if all criteria were met.

NOTE: It is permissible to perform Step 12.10.17 in any case if desired. In that case do not mark Step 12.10.19 as N/A.

____/____ 12.10.18 Record the Intermediate Range NIS overlap data at 3-4% full power on Enclosure 13.2.

____/____ 12.10.19 Perform PT/0/A/4150/23, Quarter-Core Flux Map Qualification Test.

NOTE: Testing may continue here; however, PT/0/A/4150/23, if performed now, must be complete prior to starting Step 12.11.7.

____/____ 12.10.20 Place Control Bank D at ~160 to 180 steps withdrawn to have sufficient reactivity to put the turbine on line.

____/____ 12.10.21 Verify the following:

____/____ 12.10.21.1 Acceptance criteria for each Zero Power Physics Test performed was met or any discrepancies have been resolved.

____/____ 12.10.21.2 All shutdown banks completely withdrawn and within ± 12 steps of group step counter demand position.

____/____ 12.10.21.3 Control banks above insertion limits and within ± 12 steps of group step counter demand position.

____/____ 12.10.21.4 Verify that the rod withdrawal limits are in place if they were required.

____/____ 12.10.21.5 Verify NC lowest operating loop Tave $\geq 551^{\circ}$ F.

____/____ 12.10.22 Inform the Operations Shift Supervisor that Special Test Exception Tech Spec 3.10.3 is being left. Appropriate surveillance can be stopped. Enclosure 13.1 data trending can be discontinued.

NOTE: Do not exceed 5% full power prior to completing steps 12.10.21 and 12.21.22.

____/____ 12.10.23 Review Data Book curves 6.1 and 6.3A and reissue these as needed to reflect actual measured data.

12.11 Power Escalation Testing

____/____
____/____IV

12.11.1 Reset Power Range high level trip setpoints to 109% F.P. This step need not be completed prior to going on-line, only before ~20% F.P.

NOTE: Prior to putting the turbine on-line, verify Control D bank at ~160 to 180 steps. This will ensure the availability of reactivity which will be needed while placing the turbine on-line. Make sure that Control D bank is returned to a position >200 steps before reaching 20% F.P. per Data Book Section 1.3.

____/____ 12.11.2 Verify the Power Range High Level Trip Setpoints are set to 109% full power and inform the Control Room operator of that fact. This step need not be completed prior to going on-line, only before ~20% F.P.

____/____ 12.11.3 Between 10% and 50% F.P., perform PT/0/A/4150/02A, Core Power Distribution. (It is suggested to perform this at the 30% F.P. hold for Chemistry.)

NOTE: Equilibrium xenon is not necessary for this flux map. Boron samples may be waived also.

____/____ 12.11.4 Following the flux map, perform PT/0/A/4150/23 Quarter Core Flux Map Qualfication Test. This Step can be marked N/A if it was performed in Step 12.10.19.

____/____ 12.11.5 Begin increasing reactor power from 3-4% to 50% full power at a rate of approximately 2.5% per hour (not to exceed 3% per hour). See Limit and Precaution 6.6.

NOTE: A suggested sequence for power increase is to increase load at 1 MWe/min for 30 minutes then hold for the remainder of the hour.

____/____ 12.11.5.1 As power is increased and the unit goes on-line, check all inputs to the Thermal Power Calculation by using OAC program Nuclear 28 (Thermal Power Outputs Dump). Resolve all problems prior to the 50% full power plateau.

___/___ 12.11.5.2 Record the Intermediate Range NIS overlap data at 10%, 20% and 25% full power on Enclosure 13.2.

___/___ 12.11.5.2.1 Complete Enclosure 13.5.

___/___ 12.11.5.2.2 Complete new Data Book Table 2.2.1 from the data on Enclosure 13.5.

___/___ 12.11.5.2.3 Write a procedure change to place the new Table 2.2.1 in the appropriate unit's Data Book.

___/___ 12.11.5.2.4 Generate a work request to have IAE recalibrate N35 and N36 and calibrate bistables NC-203 and NC-206 using IP/0/A/3206/02K and new Data Book Table 2.2.1.

<u>NOTE</u>: DO NOT exceed 25% Full Power until IAE has completed calibrations of Step 12.11.5.2.4.

___/___ 12.11.5.3 When approximately 40-50% full power, if the excore quadrant tilts exceed 1.02, and it is expected that these tilts might not clear within 24 hours of exceeding 50% RTP, perform the data taking for PT/0/A/4600/02F, Incore and NIS Interim Recalibration with a QCFM while reactor power is between power increases. If the excore quadrant tilts are less than 1.02, or expected to be less than 1.02, mark this step N/A.

___/___ 12.11.5.4 Record the Intermediate Range NIS overlap data at 50% full power on Enclosure 13.2.

___/___ 12.11.6 Begin increasing reactor power from 50% to approximately 80% full power at a rate of approximately 2.5% per hour (not to exceed 3% per hour). See Limit and Precaution 6.6.

___/___ 12.11.7 Perform PT/0/A/4600/02E, Incore and NIS Recalibration: Post Outage, between 50% and 80% full power.

NOTE: Closely check the data acquired in Step 12.11.7 which is to be used for calibration for consistency since some of the data was acquired at <75% full power.

___/___ 12.11.8 Record the Intermediate Range NIS overlap data at 75% full power on Enclosure 13.2.

___/___ 12.11.9 Remain below approximately 80% full power until the recalibration work performed in Step 12.11.7 is completed by I&E.

___/___ 12.11.10 While holding at below 80% power call I&E 7300 System Engineer to take data on Thot and Tcold.

___/___ 12.11.11 I&E has evaluated data gathered in Step 12.11.10 to ensure operation at 100% will be acceptable with respect to ΔT. Record in the log any I&E setpoint changes in 7300.

___/___ 12.11.12 Begin increasing reactor power from 80% to 100% full power at a rate of 2.5% per hour (not to exceed 3% per hour). See Limit and Precaution 6.6.

12.11.13 At 100% full power, perform the following tests (steps) in any order (a suggested order is listed).

___/___ 12.11.13.1 Perform PT/0/A/4150/03, Thermal Power Output Calculation.

___/___ 12.11.13.2 Perform PT/0/A/4150/02A, Core Power Distribution.

___/___ 12.11.13.3 Perform PT/0/A/4150/08, Target Flux Difference Calculation.

___/___ 12.11.13.4 Perform PT/0/A/4600/02A, Incore and NIS Correlation Check.

___/___ 12.11.13.5 Perform PT/0/A/4150/04, Reactivity Anomolies Calculation.

___/___ 12.11.13.6 Record the Intermediate Range NIS overlap data at 100% full power on Enclosure 13.2 and forward a copy of the enclosure to the appropriate I&E engineer.

___/___ 12.11.13.7 Perform PT/1 or 2/A/4150/13, NC Flow Test.

NOTE: Once Step 12.11.13.6 is complete, Step 12.11.14 may be performed.

NOTE: Perform the next two steps in any order.

___/___ 12.11.14 I&E has received data from the NC Flow Test and has made a final ΔT evaluation for the cycle at 100% F.P.

13.0 Enclosures

13.1 PAO Data

13.2 Nuclear Instrumentation Overlap Data Sheet

13.3 Nuclear Heat Determination Data Sheet

13.4 Reactivity Computer Checkout Data Sheet

13.5 Intermediate Range Channels Worksheets

13.6 Connecting the Reactivity Computer

13.7 Intermediate Range High Level Trip Setpoints

13.8 Sequence of Control Rod Banks for Rod Swap

13.9 Verification of Shutdown Martin During Rod Swap

13.10 Shutdown Margin at Zero Power

Enclosure 13.1
PAO Data
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

P1393	Control Bank D Position
A0819	Loop A T_{avg}
A0825	Loop B T_{avg}
A0831	Loop C T_{avg}
A0837	Loop D T_{avg}
A1058	Loop A ΔT
A1070	Loop B ΔT
A1082	Loop C ΔT
A1094	Loop D ΔT
A1106	Reference Temperature T_{ref}
P1355	Rx. Thermal Power - Best Estimate
P1385	Rx. Thermal Power - Best Estimate
A1081	Generator Megawatts
P1447	Primary Thermal Output %
P1445	Secondary Thermal Output %
P1469	P/R Avg. Level 1 Min. Avg. Quad. 4 (N-44)
P1467	P/R Avg. Level 1 Min. Avg. Quad. 2 (N-42)
P1466	P/R Avg. Level 1 Min. Avg. Quad. 1 (N-43)
P1468	P/R Avg. Level 1 Min. Avg. Quad. 3 (N-44)
A1006	Turbine Impulse Chamber Pressure I

Enclosure 13.2
Nuclear Instrumentation Overlap Data Sheet
Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing

	Source Range		Intermediate Range	
	N-31	N-32	N-35	N-36
Control Board	CPS	CPS	amps	amps
NIS Cabinet	CPS	CPS	amps	amps

Picoammeter __________ amps

After one decade increase on IR

	Source Range		Intermediate Range	
	N-31	N-32	N-35	N-36
Control Board	CPS	CPS	amps	amps
NIS Cabinet	CPS	CPS	amps	amps

Picoammeter __________ amps

After one decade increase on IR

	Source Range		Intermediate Range	
	N-31	N-32	N-35	N-36
Control Board	CPS	CPS	amps	amps
NIS Cabinet	CPS	CPS	amps	amps

Picoammeter __________ amps

Readings when Source Range blocked

	Source Range		Intermediate Range	
	N-31	N-32	N-35	N-36
Control Board	CPS	CPS	amps	amps
NIS Cabinet	CPS	CPS	amps	amps

Picoammeter __________ amps

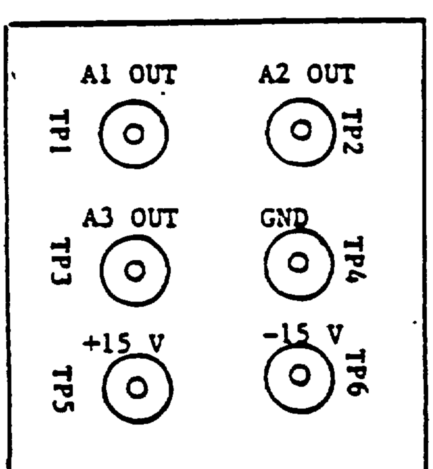
Recorded By ______________ Date ______________ Unit _____ Cycle _____
Checked By ______________ Date ______________

Enclosure 13.2
Nuclear Instrumentation Overlap Data Sheet
Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing

Power Level	Volts N-35	Volts N-36	Thermal Power, Best Est. (P1385)	Recorded By (Date/Time)
3%				
10%				
20%				
25%				
50%				
75%				
100%				

Unit ________ Cycle ________

NOTE: Data at 20 and 25% are needed to complete Enclosure 13.5. All other data are for info only.



Note: IR voltage data is to be taken inside each IR drawer. Take readings across terminals TP3 and TP4 as shown on schematic. Set Fluke to DC Volts, 0 to 10 volt scale. TP3 is a grey terminal and TP4 is a black terminal.

Enclosure 13.3
Nuclear Heat Determination Data Sheet
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

		Flux Levels (amps)		
	Time	Reac. Comp. Picoammeter from P.R. ___	N-35	N-36
Try 1 Start				
Nuclear Heat				

Try 2 Start				
Nuclear Heat				
	Avg. of 2 nuclear heat readings			

Zero Power Physics Testing Range

__________ amps to __________ amps on power range NI __________

Recorded By ________________________

Date _______________

Checked By ________________________

Date _______________

McGuire Unit _______ Cycle _____

Enclosure 13.4
Reactivity Computer Checkout Data Sheet
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

McGuire Unit ____
Cycle ____

Recorded By ____________
Date ____________
Checked By ____________
Date ____________

Date	Time	Initial Flux Level (amps) Picoammeter	Measured Doubling Time Seconds	Calculated Period Seconds	Measured Reactivity Δρc (from computer) pcm	Calculated Reactivity $\Delta\rho_{DT}$ (from period) pcm	$\left\| \frac{\Delta\rho_c - \Delta\rho_{DT}}{\Delta\rho_{DT}} \right\|$

Enclosure 13.5
Intermediate Range Channels Worksheet
Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing

Step 1: From Enclosure 13.2 record below the values of Thermal Power Best Estimate which most closely correspond to 20% and 25% power levels.

Step 2: From Enclosure 13.2 record below the voltage data given for the power levels above.

Step 3: Convert amp voltage, Eout, from Step 2 to Current, Iin, by using the following equation. Record values below on table.

$$Iin = \left\{(1 \times 10^{-4}) \left(10^{\left[\frac{Eout}{1.25} - 7\right]}\right)\right\} - 1 \times 10^{-11}$$

	Step 1 Power Level	Step 2 Eout N35 Volts	Step 2 Eout N36 Volts	Step 3 Iin Current N35 Amps	Step 3 Iin Current N36 Amps
a)					
b)					

Step 4: Complete page 2 of 3 and 3 of 3 of this enclosure by linearly extrapolating above data to 15%, 20%, 25% and 30% power as indicated, and then converting to volts as indicated.

Calculated By ______________ Date __________

Checked By ______________ Date __________

Enclosure 13.5
Intermediate Range Channels Worksheet
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

NOTE: Data is from Enclosure 13.5 page 1 of 3.

1. 20% power current for N36 (Rod Stop) = _______ amps

2. 25% power current for N36 (High Flux Trip) = _______ amps

3. 30% power current for N36 (T.S. Allowable Value) = _______ amps

4. N36 Hi Flux Rod Stop Reset at 15% RTP = _______ amps

5. N36 Hi Flux Trip Reset at 20% RTP = _______ amps

NOTE: Convert the values found in Step 1 through 5 from amps to volts using the following equation. (Round to 3 decimal places.)

$$Eout = 8.75 + 1.25 \, Log_{10}\left(\frac{Iin + Iid}{Iref}\right), \text{ volts}$$

where $Iid = 1 \times 10^{-11}$ amps

$Iref = 1 \times 10^{-4}$ amps

6. N36 20% power voltage (Rod Stop) (Use Step 1.0 as Iin) _______ volts

7. N36 25% power voltage (High Flux Trip) (Use Step 2.0 as Iin) _______ volts

8. N36 30% power voltage (T.S. Allowable Value) (Use Step 3.0 as Iin) _______ volts

9. N36 Hi Flux Rod Stop Reset at 15% Power (Use Step 4.0 as Iin) _______ volts

10. N36 Hi Flux Trip Reset at 20% Power (Use Step 5.0 as Iin) _______ volts

Calculated By _________ Date _______

Checked By _________ Date _______

Enclosure 13.5
Intermediate Range Channels Worksheet
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

NOTE: Data is from Enclosure 13.5 page 1 of 3.

1. 20% power current for N35 (Rod Stop) = _______ amps
2. 25% power current for N35 (High Flux Trip) = _______ amps
3. 30% power current for N35 (T.S. Allowable Value) = _______ amps
4. N35 Hi Flux Rod Stop Reset at 15% RTP = _______ amps
5. N35 Hi Flux Trip Reset at 20% RTP = _______ amps

NOTE: Convert the values found in Step 1 through 5 from amps to volts using the following equation. (Round to 3 decimal places.)

$$Eout = 8.75 + 1.25 \, Log_{10}\left(\frac{Iin + Iid}{Iref}\right), \text{ volts}$$

where $Iid = 1 \times 10^{-11}$ amps

$Iref = 1 \times 10^{-4}$ amps

6. N35 20% power voltage (Rod Stop) (Use Step 1.0 as Iin) _______ volts
7. N35 25% power voltage (High Flux Trip) (Use Step 2.0 as Iin) _______ volts
8. N35 30% power voltage (T.S. Allowable Value) (Use Step 3.0 as Iin) _______ volts
9. N35 Hi Flux Rod Stop Reset at 15% Power (Use Step 4.0 as Iin) _______ volts
10. N35 Hi Flux Trip Reset at 20% Power (Use Step 5.0 as Iin) _______ volts

Calculated By __________ Date _______

Checked By __________ Date _______

Enclosure 13.6
Connecting the Reactivity Computer
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

NOTE: Any one of the four power range channels may be used. For clarity NI-43 is chosen arbitrarily.

Initial/Date		
____/____ ____/____IV	13.6.1	Have IAE place Channel NI-43 in the tripped condition with input plugs removed by using the "Prerequisites" and "Removing Power Channel from Service" sections of IP/0/A/3207/03K (power range cal.) in their entirety. NOTE: This procedure does not necessarily require that the channel be placed in the tripped condition, or that the input plugs be removed. Inform the technician that these things are necessary for Performance testing.
____/____ ____/____IV	13.6.2	Verify detector A and B input plugs and high voltage plug have been disconnected.
____/____	13.6.3	Clean all three cable connectors.
____/____ ____/____IV	13.6.4	Connect the A input plug to the A connector, the B input plug to the B connector, and the HV plug to the HV connector on the Reactivity Computer Black Box.
____/____ ____/____IV	13.6.5	Connect the HV cable and P cable from the reactivity computer to the HV and Det AB Signal terminals on the Black Box.
____/____	13.6.6	Secure the Black Box to a rack mount with a tie wrap.
____/____	13.6.7	To return NI-43 to service, verify the high voltage power supply and picoammeter at the Reactivity Computer are off.
____/____		13.6.7.1 Inform Shift Supervisor you are returning NI-43 to service.
____/____ ____/____IV	13.6.8	Disconnect the A and B input plugs and the HV input plug from the Reactivity Computer Black Box.
____/____	13.6.9	Clean all three connectors.
____/____ ____/____IV	13.6.10	Have IAE return Channel NI-43 to service by performing the "Prerequisites" and "Returning Power Range Channel to Service" sections of IP/0/A/3207/03K (power range cal.) in their entirety.

Enclosure 13.7
Intermediate Range High Level Trip Setpoints
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

N-35 trip setpoint (25% full power)

= __________ amps

N-36 trip setpoint (25% full power)

= __________ amps

Recorded By ______________

Date ______________

Unit _______ Cycle _______

Enclosure 13.8
Sequence of Control Rod Banks for Rod Swap
Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing

Reference Bank	____________
First Bank	____________
Second Bank	____________
Third Bank	____________
Fourth Bank	____________
Fifth Bank	____________
Sixth Bank	____________
Seventh Bank	____________
Eighth Bank	____________

NOTE: Some of the Banks may not be measured by rod swap; mark these Banks in the sequence N/A. Indicate justification in the test log if banks will not be measured.

Recorded By ____________

Date ____________

Unit ______ Cycle ______

Enclosure 13.9
Verification of Shutdown Margin During Rod Swap
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

1. Inserted control rod worth at BOL and at zero power insertion limits (from Enclosure 13.10, Step 2) ________ pcm

2. Rod swap Reference Bank worth ________ pcm

3. Step 1. > 1.10 · Step 2. (10% conservatism on the predicted Reference Bank Worth) Yes ____ No ____

Recorded By ______________
Checked By ______________
Date ______________
Unit _____ Cycle _____

Enclosure 13.10
Shutdown Margin at Zero Power
Post Refueling Controlling Procedure for Criticality,
Zero Power Physics, and Power Escalation Testing

ntrol rod position at zero power insertion limits:

CB ________ steps withdrawn

CC ________ steps withdrawn

CD ________ steps withdrawn

serted control rod worth at BOL and at the zero power ________ pcm
sertion limits (Data Book Curve 6.3A)

L, HZP, no xenon total rod worth ________ pcm
ata Book Table 6.3.1)

ailable rod worth at BOL and at zero power insertion limits
tep 3 - Step 2) ________ pcm

rth of highest worth stuck rod at BOL ________ pcm
ata Book Table 6.3.2)

ailable Shutdown Margin at BOL and at zero power insertion limits
Step 4 - Step 5) • 0.90] ________ pcm

quired Shutdown Margin ________ pcm

ep 6 > Step 7 Yes ______ No ______

Recorded By ______________

Checked By ______________

Date ______________

Unit ______ Cycle ______

QUESTION 2

Attachment 2

FOR INFORMATION ONLY

Form 34731 (10-81)
(Formerly SPD-1002-1

DUKE POWER COMPANY
PROCEDURE PREPARATION
PROCESS RECORD

(1) ID No: PT/0/A/4150/11
Change(s) 0 to
3 Incorporated

(2) STATION: McGuire

(3) PROCEDURE TITLE: Control Rod Worth Measurement

(4) PREPARED BY: Michael S. Kitlan Jr. DATE: 3/30/84

(5) REVIEWED BY: D K Marquis DATE: 4/25/84

Cross-Disciplinary Review By: ______ N/R: DKM

(6) TEMPORARY APPROVAL (IF NECESSARY):

By: ______ (SRO) Date: ______

By: ______ Date: ______

(7) APPROVED BY: Tony L. McConnell Date: 4/26/84

(8) MISCELLANEOUS:

Reviewed/Approved By: ______ Date: ______

Reviewed/Approved By: ______ Date: ______

This copy has been compared with the
Control Copy and is verified correct.

Initial ____ Date ____ Time ____

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
CONTROL ROD WORTH MEASUREMENT

1.0 Purpose

1.1 To measure the differential and integral worth of any of the Controlling Banks or Shutdown Banks.

1.2 To measure the differential boron worth over the range being tested.

2.0 References

2.1 Rod and Boron Worth Measurements During Boron Dilution, DAP/DBP-SU-7.4.

3.0 Time Required

3.1 2 hours, 2 engineer for each Rod Bank measured.

4.0 Prerequisite Tests

None

5.0 Test Equipment

5.1 Reactivity Computer (with flux signal from top and bottom of one power range channel).

5.2 Two pen strip chart recorder with reactivity and T_{avg} signals.

5.3 Two pen strip chart recorder with pressurizer water level and flux signal.

6.0 Limits and Precautions

6.1 The NC System temperature is controlled preferably by secondary steam bypass to the condenser or by secondary steam dump to the atmosphere. Temperature control may alternatively by affected by steam generator blowdown.

6.2 Normally all reactor coolant pumps should be operating for maximum mixing in the NCS. If all reactor coolant pumps are not operating, the operating pumps should be those on the NCS charging loops (A&D). See Tech Spec 3.4.1.1 and 3.10.4 if all reactor coolant pumps are not operating.

6.3 The rod insertion limit will be violated during this test. The operators should be made aware in advance and should anticipate the associated alarms. Technical Specification 3.10.3 allows for this.

6.4 Chart speeds for rod worth measurements should be about .2 to 1 in./min. The sawtooth of the reactivity trace should be kept at about a 45° angle.

7.0 Required Unit Status

Initial/Date

____/____ 7.1 The unit is just critical in the Startup Mode (Mode 2) at zero power with the flux level in the required testing range.

____/____ 7.2 Record in the log the unit to which this test applies.

8.0 Prerequisite System Conditions

____/____ 8.1 The reactor coolant system pressure is at 2235 ±50 psig.
NOTE: Maintain NCS pressure within ±25 psig of established pressure during the test.

____/____ 8.2 The reactor coolant system temperature is 557°F +1, -5°F.
NOTE: Maintain NCS temperature within ±1°F of established temperature during the test.

____/____ 8.3 ~~The pressurizer spray control is in manual with spray flow established at the maximum rate consistent with pressurizer heater capability.~~
Pressurizer Control is set to maximize press per capability
[illegible] 5-1-85

____/____ 8.4 Test equipment is set up per Section 5.0.

____/____ 8.5 The unit is sufficiently stable as determined by the test coordinator.

____/____ 8.6 The indicated core reactivity is less than ±1 pcm.

____/____ 8.7 Record the requested data on Enclosure 13.1 for this step.

____/____ 8.8 The Control Rods are positioned as specified by the Test Coordinator.

____/____ 8.9 Complete Enclosure 13.4 only if no overlap data is to be taken. Mark this step, Step 8.9.1, and Enclosure 13.4 N/A if overlap data is to be taken.

____/____ 8.9.1 Bank selector switch is positioned in bank select to the bank being measured if 8.9 is not N/A.

__/__ 8.10 Complete Enclosure 13.5 only if overlap data is to be taken. Mark this step, Step 8.10.1 and Enclosure 13.5 N/A if this is not the case.

__/__ 8.10.1 Bank select switch is in overlap (manual) unless 8.10 is N/A.

9.0 Test Method

With the RCCA's positioned as requested by the Test Coordinator, the amount of demineralized water/boric acid required to compensate for the forthcoming configuration adjustment is determined. A continuous boron concentration change is initiated at a rate of approximately 500 pcm/hr. The RCCA's are moved in discrete increments to compensate for the change in boron concentration. From the data gathered, the differential and integral worth of RCCAs being measured is determined.

10.0 Data Required

10.1 Rod positions and reactivity will be recorded on Enclosure 13.1.

10.2 The following data should be recorded on the strip charts: (attach charts to this procedure)

10.2.1 RCCA positions before and after each discrete increment.

10.2.2 Parameter scale and chart speed should be written on the chart.

10.3 Plot of integral and differential rod worth on Enclosure 13.2.

10.4 Predicted data on Enclosure 13.4.

11.0 Acceptance Criteria

11.1 The rod worth of the rod or bank being measured is within ±10% of the predicted rod worth as given on Enclosure 13.4.

11.2 The integral rod worth of Control Banks A, B, D, D in overlap is within ±4% of the total measured values of Control Banks A, B, C and D individually as given on Enclosure 13.5. This <u>only</u> applies if overlap data is to be taken.

CH. #5 6/26/85

11.3 IF THE BANK BEING MEASURED IS THE REFERENCE BANK FOR ROD SWAP, THE ABSOLUTE VALUE OF THE PERCENT DIFFERENCE BETWEEN MEASURED AND PREDICTED INTEGRAL WORTH IS ≤ 15 %.

NOTE: THIS ACCEPTANCE CRITEREON DOES NOT APPLY IF THE BANK BEING MEASURED IS THE REFERENCE BANK FOR ROD SWA[P]

CH. 6/

12.0 Procedure

Initial/Date

NOTE: The following steps explain the general method for performing rod worth measurements for single RCCA's, Groups of RCCA's, or Banks of RCCA's during either dilution or boration.

___/___ 12.1 Verify that the strip chart recorders specified in Section 5.0 are operable and set up as required.

___/___ 12.2 Determine the amount of demineralized water/boric acid to compensate for the required configuration adjustment. See Enclosure 13.3 for an example of how to determine this.

___/___ 12.3 Record the beginning boric acid and primary water integrator values in the test log. If possible, reinitialize readings to 0.0.

___/___ 12.4 Using the reactivity computer, measure the worth of the bank being tested from its current position to the fully withdrawn/inserted position. Record the data on Enclosure 13.1.

NOTE: This is similar to a Boron Endpoint Measurement.

___/___ 12.5 Using the number obtained in Step 12.2, initiate the required boron concentration change at a rate which will not cause a reactivity rate of change of >500 pcm/hr.

NOTE: This guideline corresponds to a dilution rate of approximately 2500 gallons per hour (40 GPM) or a boration rate of approximately 250 gallons per hour (4 GPM) of 4 w/o boric acid. See Enclosure 13.3 for an example of this.

___/___ 12.6 Insert/withdraw RCCA's in discrete increments in order to compensate for dilution/boration. These increments should be limited such that the resultant reactivity change are within the guidelines of approximately ±20 pcm. During these measurements, record all relevant data on the strip charts in use. See Section 10.2.

___/___ 12.7 Terminate the boron concentration change such that the desired rod configuration is achieved.

NOTE: A delay of some minutes (typically 15 minutes) is unavoidable between termination of the transient and stabilization. This delay should be anticipated.

NOTE: Normally the desired rod configuration will be either overshot or undershot. The Test Coordinator must evaluate the effects of this situation on the results of the affected test. If effects are unacceptable, the Test Coordinator can repeat Steps 12.2 through 12.5 to correct the situation.

NOTE: If there is any overshoot, the bank selector switch may be changed to the next bank.

NOTE: For rod swap measurements, terminate the boron concentration change such that the final position of the bank is almost to the fully inserted position.

__/____ 12.8 Using the reactivity computer, measure the worth of the bank being measured from its current position to the fully inserted/withdrawn position. Record the data in the test log for later entry into Enclosure 13.1. Mark this step as N/A if this data is already obtained (i.e., overshoot to next bank).

NOTE: This is similar to a Boron Endpoint Measurement.

__/____ 12.9 Record the final primary water and/or boric acid integrator values in the test log.

__/____ 12.10 Record the "FINAL" data requested on Enclosure 13.1.

__/____ 12.11 After the test is over, record the required data on Enclosure 13.1 from the strip charts.

__/____ 12.12 Verify the acceptance criteria has been met.

__/____ 12.13 Using the data on Enclosure 13.1, complete the plot(s) on Enclosure 13.2.

__/____ 12.14 In the log, calculate the differential boron worth over the bank being measured by dividing the measured rod worth by the difference in boron concentration over the rod worth measurement.

13.0 Enclosures

13.1 Rod Worth Measurement Data Sheet

13.2 Rod Worth Curves

13.3 Example of Determination of Dilution Rate

13.4 Predicted Rod Worth Data

13.5 Rod Worth Data if Worths in Overlap are to be Taken

Control Rod Worth Measurement
Enclosure 13.1
Rod Worth Measurement Data Sheet

Step 8.7 McGuire Unit _____ Cycle _____

Bank or RCCA Identification __________ Boration ☐ Dilution ☐ (Check one)

Date ______________ Power (amps) ______________

Initial Shutdown Bank Positions: A_____ B_____ C_____ D_____ E_____.

Initial Control Bank Positions: A_____ B_____ C_____ D_____

Overlap Measurement (yes or no) _____

	Initial	Final (Step 12.10)
NCS Boron Concentration (ppm):		
Pressurizer Boron Concentration (ppm):		
NCS Temperature (T_{avg}) ^{o}F:		
NCS Pressure, psig:		

Step 12.9

Time	RCC Position (Steps Withdrawn)			Delta H	Reactivity (pcm)		
	Initial	Final	Average	(Δh)	$\Delta\rho$	$\Sigma\ \Delta\rho$	$\Delta\rho/\Delta h$

REMARKS ____

____

Recorded By ______________________ Page ___ of ___

Date

Control Rod Worth Measurement
Enclosure 13.1
Rod Worth Measurement
Data Sheet

Step 12.9 (continued)

Time	RCC Position (Steps Withdrawn)			Delta H	Reactivity (pcm)		
	Initial	Final	Average	(Δh)	Δρ	Σ Δρ	Δρ/Δh

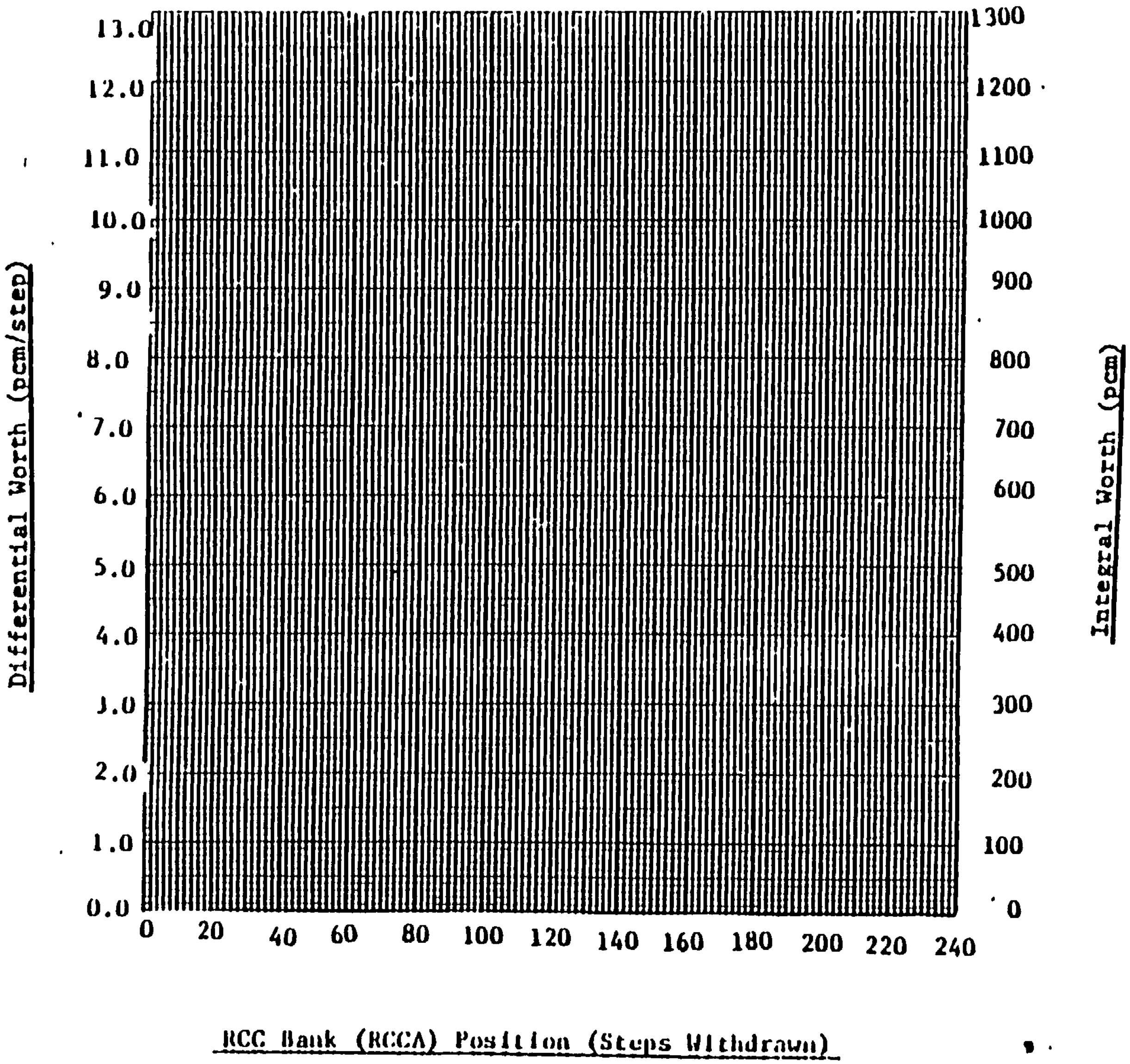
REMARKS ____

____

Recorded By ____________________ Page ___ of ___

Control Rod Worth Measurement
Enclosure 13.2
Rod Worth Curves

Differential and Integral RCC Bank (RCCA) Worth



McGuire Unit: ____________

Bank: ____________

Date: ____________

Test Conditions:

1. RCC Bank Positions:
   - SDA ____________
   - SDB ____________
   - SDC ____________
   - SDD ____________
   - SDE ____________
   - CA ____________
   - CB ____________
   - CC ____________
   - CD ____________
2. Power Level:
   ____________ amps
3. NC Temp.:
   - Initial: ____________ °F
   - Final: ____________ °F
4. NC Press.:
   - Initial: ____________ °F
   - Final: ____________ °F
5. Avg. Core Burnup:
   ____________ MWD/MTU
   ____________ efpd

Control Rod Worth Measurement
Enclosure 13.3
Example of Determination of Dilution Rate
(Illustration Purposes Only)

It is desired to dilute Control Bank B from 223 to 0 steps at a rate not to exceed 500 pcm/hr.

1. The starting point is known: Initial Boron Concentration is 1130 ppm.

2. Go to Figure A.3 in the Core Design Report (or any other applicable document). The Integral Rod worth for Control Bank B from 223 to 0 is 909 pcm.

3. Go to Curve 6.2 in the Data Book at 1130 ppm BOL and get -10.7 pcm/ppm for the differential boron worth.

4. 990 pcm ÷ 10.7 pcm/ppm = -92.5 ppm change (dilute)

5. 1130 ppm - 92.5 ppm = 1037 ppm ending boron concentration.

6. Go to Figure 5.1 in the Data Book. To go from 1130 to 1037 ppm, add about 5656 gallons of demineralized water.

7. An alternate method is to use the Boron Predict Program on the OAC.

8. The maximum rate is 500 pcm/hr; therefore:

$$\frac{5656 \text{ gal.}}{990 \text{ pcm}} \times \frac{500 \text{ pcm}}{\text{hour}} \times \frac{1 \text{ hour}}{60 \text{ min.}} = 47.6 \text{ gpm}$$

9. To be conservative, go at 45 gpm.

10. Expect the time for the rod worth measurement to be

$$\frac{990 \text{ pcm}}{500 \text{ pcm/hr}} \cong 2 \text{ hours}$$

Control Rod Worth Measurement
Enclosure 13.4
Predicted Rod Worth Data

Step 8.9

Complete one of the following two lines. Mark the other N/A.

Bank Being Measured (i.e., Control/Shutdown) ____________________
Rod Being Measured ____________________

Predicted Rod Worth Value for the above condition.

____________ pcm ±10%

OR

____________ pcm ± ____________ pcm

This information was transmitted to McGuire Nuclear Station by/in (list reference):

____

Reason for this test (refueling, etc.): ____________________
____

Recorded By ____________________
Date ____________________
McGuire Unit ____________________
Cycle ____________________

Control Rod Worth Measurement
Enclosure 13.5
Rod Worth Data if Worths in Overlap are to be Taken

Step 8.10

Individual Measured Rod Worth Values (not in overlap):

Control Bank A ______________ pcm
Control Bank B ______________ pcm
Control Bank C ______________ pcm
Control Bank D ______________ pcm

Sum of Control Bank A, B, C and D individual rod worths: ______________ pcm ±4%

OR

______________ pcm ± ______________ pcm

The above individual measured rod worth values were obtained from (list procedures):

____

which were performed on (list dates): ____________________________________

Recorded By ______________________
Date ______________________
McGuire Unit ______________________
Cycle ______________________

rm 34805 (7-81)

Sheet ____ of ____

Procedure No. PT/0/A/4150/11

Test Logger ____

DUKE POWER COMPANY

McGuire NUCLEAR STATION

TEST LOG

Date	Time	Remarks	Initial

QUESTION 2

Attachment 3

Form 34731 (R8-85)

FOR INFORMATION ONLY

(1) ID No PT/0/A/4150

Change(s) 0 to 5 Incorporated

PREPARATION

(2) STATION McGuire

(3) PROCEDURE TITLE Control Rod Worth Measurement: Rod Swap

(4) PREPARED BY L J Kunks DATE 6/10/86

(5) REVIEWED BY M. Todd Killer DATE 6/10/86

Cross-Disciplinary Review By N/R MTK

(6) TEMPORARY APPROVAL (If Necessary)

By (SRO) Date

By Date

(7) APPROVED BY Bruce Hamilton DATE 6/11/86

(8) MISCELLANEOUS

Reviewed/Approved By Date

Reviewed/Approved By Date

(9) COMMENTS (For procedure reissue indicate whether additional changes, other than previously approved changes, are included. Attach additional pages, if necessary.) ☒ ADDITIONAL CHANGES INCLUDED.

COMPLETION

(10) COMPARED WITH CONTROL COPY TWMirna DATE 1/29/87

(11) DATE(S) PERFORMED

(12) PROCEDURE COMPLETION VERIFICATION

- ☐ Yes ☐ N/A Check lists and/or blanks properly initialed, signed, dated or filled in N/A or N/R, as appropriate?
- ☐ Yes ☐ N/A Listed enclosures attached?
- ☐ Yes ☐ N/A Data sheets attached, completed, dated and signed?
- ☐ Yes ☐ N/A Charts, graphs, etc. attached and properly dated, identified and marked?
- ☐ Yes ☐ N/A Acceptance criteria met?

VERIFIED BY DATE

(13) PROCEDURE COMPLETION APPROVED DATE

(14) REMARKS (Attach additional pages, if necessary.)

RECEIVED FEB 3 1987

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
CONTROL ROD WORTH MEASUREMENT:
ROD SWAP

1.0 Purpose

1.1 To verify that the reactivity worth of the Reference RCC bank, as determined through reactivity computer measurement data, is consistent with design predictions.

NOTE: The reference RCC bank is the bank which has the predicted highest reactivity worth of all control and shutdown banks when inserted into an otherwise unrodded core.

1.2 To verify that the reactivity worth of each control and shutdown bank (except the reference bank), as inferred from data following iso-reactivity interchange with the reference bank, is consistent with design predictions.

2.0 References

2.1 Rod Bank Worth Measurements Utilizing Bank Exchange, WCAP-9863-A, May 1982.

2.2 Control Rod Worth Measurement, PT/0/A/4150/11

2.3 Post Refueling Controlling Procedure for Criticality, ZPPT, and Power Escalation Testing, PT/0/A/4150/21

2.4 Technical Specifications 3.4.1.1, 3.10.4, 3.10.3, and 3.10.2.

3.0 Time Required

3.1 8 hours, 1 engineer

4.0 Prerequisite Tests

Initial/Date

____/____ 4.1 PT/0/A/4150/10, ARO Boron Endpoint Measurement

NOTE: It is only necessary to obtain a value for ARO Boron Endpoint.

5.0 Test Equipment

5.1 Reactivity Computer (with flux signal from top and bottom of one power range channel).

5.2 Two two-pen strip chart recorders. One chart recorder should have reactivity (on a scale of 10 pcm/inch, with 0 pcm being the center of the recorder sheet), and T_{avg} from one loop (on a scale of 1°F/inch for 556 to 558°F set up on one side of the recorder sheet). The other chart recorder should have flux (on a scale of 0 to the top end of the testing decade in amps) and pressurizer level (on a scale of 10% level/inch). Chart speeds should be 1 inch/min.

NOTE: The specifications in this step may be altered by the Test Coordinator as necessary to accommodate equipment limitations, as long as all four signals are recorded or trended.

6.0 Limits and Precautions

6.1 The NC system temperature is controlled preferably by steam dump to the condenser. Temperature control may alternatively be affected by steam generator blowdown.

6.2 Normally all reactor coolant pumps should be operating for maximum mixing in the NCS. If all reactor coolant pumps are not operating, the operating pumps shoul1 be those on the NCS charging loops (A and/or D). See Tech Spec 3.4.1.1 and 3.10.4 if all reactor coolant pumps are not operating.

6.3 The rod insertion limit and bank overlap sequence will be violated during this test. The operators should be made aware in advance and should anticipate the associated alarms. Technical Specification 3.10.2 and 3.10.3 allows for this.

6.4 Maintain the flux level in the zero power test range established in Reference 2.3.

6.5 Prior to switching the rod control selector switch from one bank to another, verify both groups of the bank (if the bank has two groups) are at the same position in order to avoid group misalignment.

7.0 Required Unit Status

Initial/Date

____/____ 7.1 The unit is just critical in the Startup Mode (Mode 2) at zero power with the flux level in the zero power test range established in PT/0/A/4150/21, "Post Refueling Controlling Procedure for Criticality, ZPPT, and Power Escalation Testing."

____/____ 7.2 Record in the log the unit and cycle to which this test applies.

8.0 Prerequisite System Conditions

NOTE: The following steps may be signed off in any order.

____/____ 8.1 The reactor coolant system temperature is 557°F +1, -5°F.

NOTE: Maintain NCS temperature within ±1°F of established temperature during the test.

____/____ 8.2 The difference between NC loop, pressurizer, and VCT boron concentrations is less than 20 ppm. List on Enclosure 13.3.

NOTE: Do not use the boronometer.

Boron samples are desirable but are not necessary for completion of test. Samples may be waived if reason is logged in the test log. Samples may be taken during the data taking at the test coordinator's request.

____/____ 8.3 Xenon worth rate is changing less than ±.1 pcm/min.

____/____ 8.4 Test equipment is set up per Section 5.0.

____/____ 8.5 All available pressurizer heaters are on as needed, in order to improve mixing by maximizing the pressurizer spray.

____/____ 8.6 All control and shutdown banks are fully withdrawn except Control Bank D which is at a position greater than about 215 steps withdrawn.

____/____ 8.7 The Rod Control Selector switch is in Bank Select Mode set on Control Bank D.

____/____ 8.8 Complete Enclosure 13.1 with the predicted data. See Reference 2.3, Enclosure 13.8 for banks to be measured. See Enclosure 13.2 for an explanation of nomenclature used in this test.

NOTE: If any banks are not being measured mark the blanks on Enclosure 13.1 N/A.

9.0 Test Method

The RCC bank with the highest predicted value of reactivity worth is measured using the dilution technique per PT/0/A/4150/11. This bank serves as a reference. The integral worth of the remaining RCC banks is implied from the difference in the critical rod position of the reference bank with and without the insertion of bank being tested. The implied integral worths are then compared to predicted rod worths.

10.0 Data Required

10.1 The following conditions for the approximate time of criticality before each bank exchange, recorded on Enclosure 13.4:
Time
Just critical height of reference bank

10.2 Nuclear design predictions on Enclosure 13.1.

10.3 Boron concentration information for the NCS and pressurizer on Enclosure 13.3. Boron samples are desirable but are not necessary for completion of test. Samples may be waived if the reason is logged in the test log.

10.4 A copy of the rod positions and rod worths for the reference bank from Enclosure 13.1 of PT/0/A/4150/11 when this test is complete.

10.5 The calculated, implied integral worth (W_x^I) for each RCC bank except the reference bank. List data on Enclosure 13.4.

10.6 The percent difference between inferred and predicted worths for each individual RCC banks (ε_1) and for the sum of all banks (ε_2) on Enclosure 13.5.

11.0 Acceptance Criteria

11.1 The absolute value of the percent difference between measured and predicted integral worth for the reference bank is ≦15% (from Enclosure 13.5 $(\varepsilon_1)_1$ ≦15%).

11.2 From Enclosure 13.5, the calculated value ε_2 ≦10%.

11.3 For all RCC banks other than the reference bank; either:

a) From Enclosure 13.5, ε_{1_x} ≦30% for each bank or

or

b) $W_x^I - W_x^P$ ≦200 pcm for each bank,

whichever is greater.

12.0 Procedure

Initial/Date

NOTE: See Enclosure 13.2 for an explanation of all nomenclature used in this test.

12.1 Measure the integral reactivity worth of the reference bank as follows:

NOTE: The reference bank is defined as that bank which is predicted to have the highest worth, of all control and shutdown banks, when inserted into an otherwise un-rodded core (see Enclosure 13.1 for the identity of this bank). In this procedure, all banks will be referred to by the bank number, except the reference bank. If the reference bank is currently positioned at less than 228 steps withdrawn (i.e., if it is Control Bank D), continue with step 12.1.5. Mark steps 12.1.1 to 12.1.4 NA. If the reference bank is positioned at 228 steps withdrawn, continue on at Step 12.1.1.

____/____ 12.1.1 Insert the reference bank until the indicated reactivity is approximately -10 pcm.

____/____ 12.1.2 Withdraw the bank inserted below 228 until the indicated reactivity is approximately +10 pcm.

____/____ 12.1.3 Repeat steps 12.2.1 and 12.2.2 until the previously inserted bank is fully withdrawn.

____/____ 12.1.4 Adjust the position of the reference bank until the reactor is just critical. Record this position in the test log.

____/____ 12.1.5 Perform Control Rod Worth Measurement per PT/0/A/4150/11 on the reference Bank.

____/____ 12.1.6 Attach a completed copy of PT/0/A/4150/11 Enclosure 13.1 to this procedure.

____/____ 12.1.7 Record the total reference bank rod worth from PT/0/A/4150/11 Enclosure 13.1 on Enclosure 13.4 as shown.

____/____ 12.1.8 Ensure the reactor is critical at the same reference bank position as was obtained at the end of PT/0/A/4150/11.

12.2 Measure the reactivity worth of the remaining control and shutdown banks, relative to the reference bank, as follows:

NOTE: The relative worth of each RCC bank is obtained from the critical position of the reference bank (initially nearly fully inserted) after full insertion of the bank being measured (initially fully withdrawn), at constant RCS boron concentration.

____/____ (√) ___ ___ ___ ___ ___ 2 3 4 5 6 ___ ___ 7 8

12.2.1 Record the initial critical bank configuration on Enclosure 13.4 for the reference bank.

____/____ (√) ___ ___ ___ ___ ___ 2 3 4 5 6 ___ ___ 7 8

12.2.2 Insert bank 1 (identify this bank on top of Enclosure 13.5; i.e., Bank 1 is S/D E or Cont. B, etc.) until the reactivity indicated by the reactivity computer is approximately -20 pcm.

____/____ (√) ___ ___ ___ ___ ___ 2 3 4 5 6 ___ ___ 7 8

12.2.3 Withdraw the reference Bank until the indicated reactivity is approximately +20 pcm.

NOTE: Maintain the flux within the zero power test range established in Reference 2.4.

____/____ (√) ___ ___ ___ ___ ___ 2 3 4 5 6 ___ ___ 7 8

12.2.4 Repeat Steps 12.4.2 and 12.4.3 until bank 1 is fully inserted. Keep the indicated reactivity within ±20 pcm.

____/____ (√) ___ ___ ___ ___ ___ 2 3 4 5 6 ___ ___ 7 8

12.2.5 Adjust the position of reference bank until the reactor is just critical. Record the final critical configuration data on Enclosure 13.4.

____/____ (√) ___ ___ ___ ___ ___ 2 3 4 5 6 ___ ___ 7 8

12.2.6 Insert the reference Bank 1 until the indicated reactivity is approximately -20 pcm.

___/___ 12.2.7 Withdraw bank 1 until the indicated reactivity is approximately +20 pcm.

(√) ___ ___ ___ ___ ___
2 3 4 5 6

___ ___
7 8

___/___ 12.2.8 Repeat Steps 12.4.6 and 12.4.7 until bank 1 is fully withdrawn.

(√) ___ ___ ___ ___ ___
2 3 4 5 6

___ ___
7 8

___/___ 12.2.9 Adjust the position of reference Bank until the reactor is just critical. Record the critical configuration data on Enclosure 13.4.

(√) ___ ___ ___ ___ ___
2 3 4 5 6

___ ___
7 8

___/___ 12.2.10 Repeat Steps 12.4.2 through 12.4.9 for the remaining, unmeasured control and shutdown banks numbered 2 through 8 instead of bank 1. Identify the bank beside the bank number on Enclosure 13.4.

NOTE: If any banks are not being measured mark the blanks on Enclosure 13.4 and the check off blanks in step 12.4.2 through 12.4.9 N/A.

___/___ 12.3 Have Chemistry take a NC & pressurizer boron sample and write the results on Enclosure 13.2.

NOTE: The test may continue while waiting for the boron samples.

NOTE: This completes the data acquisition section of the test.

___/___ 12.4 Compute the average of the reference bank critical position on Enclosure 13.4.

12.5 Compute the inferred worth for each control and shutdown bank (except the reference bank) as follows:

___/___ 12.5.1 Using the data from Enclosure 13.4, and the worth measurement data for the reference bank from Enclosure 13.1 of PT/0/A/4150/11, compute the value of $(\Delta\rho_1)_x$ as described below and record on Enclosure 13.4:

$$(\Delta\rho_1)_x = \left[W_R^M\right]_o^{(h_x^M)_o \text{ avg}}$$

where:

$\left[W_R^M\right]_o^{(h_x^M)_o \text{ avg}}$ is the measured integral worth of the reference bank from 0-steps to $(h_x^M)_o$ avg from Enclosure 13.1.of PT/0/A/4150/11.

NOTE: Linearly interpolate if $(h_x^M)_o$ avg does not correspond to the steps on Enclosure 13.1 of PT/0/A/4150/11.

and $(h_x^M)_o$ avg is the average of the initial and return critical positions of the reference bank before and after interchange with bank x as given on Enclosure 13.4.

____/____ 12.5.2 Using the data from Enclosure 13.4, the worth measurement data for the reference bank from Enclosure 13.1 of PT/0/A/4150/11 and the design data of Enclosure 13.1, compute the value of $\alpha_x\ (\Delta\rho_2)_x$ as described below and record on Enclosure 13.4:

$$\alpha_x(\Delta\rho_2)_x = \alpha_x \left[W_R^M\right]_{h_x^M}^{228}$$

where: $\left[W_R^M\right]_{h_x^M}^{228}$ is the measured integral worth of the reference bank from h_x^M to the fully withdrawn position from PT/0/A/4150/11, Enclosure 13.1. Linearly interpolate if h_x^M does not correspond to the steps on PT/0/A/4150/11 Enclosure 13.1.

using measured IRW for Ref Bank based on h_x^m

h_x^M is the measured critical position of the reference bank after interchange with bank x from Enclosure 13.4.

and

α_x is a correction factor from Enclosure 13.1 to account for the influence of bank x on the worth of the reference bank.

Note: If bank being measured has a worth greater than the Reference Bank worth, see Enclosure 13.6 Replace $\alpha_x(\Delta\rho_2)_x$ with WE on Enclosure 13.4.

Chow
mx
6/23/86

___/___ 12.5.3 Compute the inferred integral worth of each bank x, W_x^I, as described below and record on Enclosure 13.4:

$$W_x^I = W_R^M - (\Delta\rho_1)_x - \alpha_x(\Delta\rho_2)_x$$

where: W_R^M is the measured total integral reference bank worth from PT/0/A/4150/11 Enclosure 13.1.

$(\Delta\rho_1)_x$ is from step 12.5.1.

and

$\alpha_x(\Delta\rho_2)_x$ is from step 12.5.2

Ch 06
[illegible]
6/23/86

Note: If Bank being recovered has a worth greater than the reference bank worth, compute the inferred integral worth of the bank as shown on Enclosure 13.6, where WE is given in the column marked $\alpha_x(\Delta\rho_2)_x$ on Enclosure 13.4 and WRo is given in the column marked $(\Delta\rho_1)_x$ on Enclosure 13.4.

____/____ 12.5.4 Compute the percent difference between inferred and predicted worths for each individual RCC bank and the sum of all banks described below.

$$(\varepsilon_1)_x = \left[\frac{W_x^I - W_x^P}{W_x^P}\right] \times 100\text{, in }\%$$

$$\varepsilon_2 = \left[\frac{\sum_{i=1}^{N} W_i^I - \sum_{i=1}^{N} W_i^P}{\sum_{i=1}^{N} W_i^P}\right] \times 100\text{, in }\%$$

Fill in all blanks and summarize the calculations on Enclosure 13.5.

____/____ 12.6 Verify all acceptance criteria have been met.

13.0 <u>Enclosures</u>

13.1 Nuclear Design Predictions for Rod Interchange Measurements

13.2 Nomenclature

13.3 Log of Boron Concentrations

13.4 Critical Configuration Data

13.5 Comparison of Inferred Bank Worths with Design Predictions

13.6 Letter on Rod Swap

Control Rod Worth Measurement: Rod Swap
Enclosure 13.1
Nuclear Design Predictions
for Rod Interchange Measurements

McGuire Unit _____ Cycle _____

Bank No. (x)	Bank Identity +	W_x^P (pcm)	(b) h_x^P (steps)	(c) α_x
Reference (a)				
1				
2				
3				
4				
5				
6				
7				
8				

(a) Reference bank - the bank with the highest predicted integral worth.

(b) Reference bank critical position after interchange with bank x.

(c) Ratio of integral worth of the reference bank from h_x^P to the fully withdrawn position with and without x in the core.

\+ Control Bank C, Shutdown Bank E, etc.

NOTE: See Enclosure 13.2 for a complete listing of nomenclature used in this test.

Recorded By ____________________ Date ________________
This data came from (list source): ________________________________

____

Control Rod Worth Measurement: Rod Swap
Enclosure 13.2
Nomenclature

1. W_x^P Predicted reactivity worth of each control and shutdown bank when inserted individually into an otherwise unrodded core.

2. W_x^I The calculated, implied rod bank worths of bank x from rod exchange

3. W_R^M Measured rod bank worth of reference bank

4. α_x A correction factor which accounts for the effect of bank x on the partial integral worth of the reference bank, equal to the ratio of the integral worth of the reference bank from h_x^P to the fully withdrawn position with and without x in the core.

5. $(\Delta\rho)_x$ The measured integral worth of the reference bank from h_x^M to the fully withdrawn position.

6. h_x^P The predicted critical position of the reference bank after interchange with bank x starting with reference bank at 0, bank x fully withdrawn.

7. h_x^M The measured critical position of the reference bank after interchange with bank x.

8. $\left[W_R^M\right]_o^{(h_x^M)_{o\ avg}}$ Is the measured integral worth of the reference bank from 0 steps to $(h_x^M)_{o\ avg}$

9. $(h_x^M)_{o\ avg}$ Is the average of the initial and return critical positions of the reference bank before and after interchange with bank x.

10. $\left[W_R^M\right]_{h_x^M}^{228}$ Is the measured integral worth of the reference bank from h_x^M to the fully withdrawn position.

Control Rod Worth Measurement: Rod Swap
Enclosure 13.3
Log of Boron Concentrations

Date	Time Sample Taken	NCS Boron Concentrations			Comments	Recorded By
		+VCT	NCS	Press.		

McGuire Unit ___________
Cycle _____

NOTE: VCT sample needed only once at start of the test. Mark this block as N/A after this.

Init _____ Cycle _____

Control Rod Worth Measurement: Rod Swap
Enclosure 13.4
Critical Configuration and Worth Calculation Sheet

[illegible]

Bank (x)		Date	Time	$(h_x^M)_o$ (steps)			h_x^M (steps)	★ $(\Delta\rho_1)_x$	★ $\alpha_x(\Delta\rho_2)_x$	★ W_x^I
No.	Ident.			Initial (step 12.2.1)	Return (step 12.2.9)	Average (step 12.4)	(step 12.2.5)	(pcm) (step 12.5.1)	(pcm) (step 12.5.2)	(pcm) (step 12.5.3)
1										
2										
3										
4										
5										
6										
7										
8										

★ NOTE: IF BANK BEING MEASURED HAS A WORTH GREATER THAN THE REFERENCE BANK WORTH, THESE VALUES WILL BE AS GIVEN IN STEPS 12.5.2 AND 12.5.3 AND ENCLOSURE 13.6

[illegible]

Recorded By ____________________ Date ________

Checked By ____________________ Date ________

Step 12.1.7 W_R^M = ______ pcm

Control Rod Worth Measurement: Rod Swap
Enclosure 13.5
Comparison of Inferred Bank Worths
With Design Predictions

Unit _____ Cycle _____
Date _________________

Bank (x)		++ W_x^I	* W_x^P	$(\varepsilon_1)_x$
No.	Ident.	(pcm)	(pcm)	(%)
reference		+		
1				
2				
3				
4				
5				
6				
7				
8				

$\sum W_x^I$ (pcm)	$\sum W_x^P$ (pcm)	ε_2 (%)

tep 12.2.7: Record the measured worth of the reference bank here.

rom Enclosure 13.1

from Enclosure 13.4

Recorded By ____________________ Date______

Checked By ____________________ Date______

From: LANGFORD.F.L (WES1974) Posted: Wed 10 Apr-85 9:06 EST Sys 49
Subject: Rod Swap Information for Mike Kitlan

...n, please forward this to Mike Kitlan.

...e,

...s is to document our telecon on 4/9/85 on the actions to be taken ...n the test bank could be worthore than the reference bank for the ... Swap bank worth measureoent. When this occurs, the following ...ints should be noted:

1) Do not change the reference bank designation.

2) Exchange the highest worth test bank last.

3) With the reference bank fully out and the test bank nearly fully inserted, measure the remaining worth of the test bank by one of two methods.

   a) Perform an "endpoint type" maneuver and insert the test bank from the critical position to zero steps and measure the reactivity worth using the reactivity computer.

   b) If the remaining worth of the test bank is larger than approximately 50 pcm, then dilute the test bank in from the critical position to zero steps and measure the reactivity worth using the reactivity computer. This will render the measurement of the just critical position of the reference bank alone after the swap N/A.

4) The worth of the test bank will be equal to the total worth of the reference bank plus the measured remaining worth of the test bank minus the worth of the reference bank from just critical to zero steps. Or in equation form:

$$WX = WR + WE - WRo$$

where: WX is the worth of the test bank,

WR is the total worth of the reference bank,

WE is the remaining worth of the test bank with the reference bank fully withdrawn, and

WRo is the worth of the reference bank from the just critical position to fully inserted (Delta-Rho-1 in the procedure).

Note that Alpha-x times Delta-Rho-2-x (procedure notation) is not used since Delta-Rho-2-x is zero.

...opefully this meets your documentation requirements for this unique ...roblem. Also note that this was done at Zion last year without any ...roblems.

...egards,
. R. Grobmyer
...estinghouse NTD
...uclear Operations

QUESTION 5

FOR INFORMATION ONLY

Attachment 4

Form 34731 (10-81)
(Formerly SPD-1002-1)

DUKE POWER COMPANY
PROCEDURE PREPARATION
PROCESS RECORD

(1) ID No: PT/0/A/4150/11A
Change(s) 0 to
0 Incorporated

(2) STATION: McGuire

(3) PROCEDURE TITLE: Control Rod Worth Measurement: Rod Swap

(4) PREPARED BY: Michael S. Kitlan Jr. DATE: 4/4/84

(5) REVIEWED BY: ______ DATE: ______

Cross-Disciplinary Review By: ______ N/R: ______

(6) TEMPORARY APPROVAL (IF NECESSARY):

By: ______ (SRO) Date: ______

By: ______ Date: ______

(7) APPROVED BY: ______ Date: ______

(8) MISCELLANEOUS:

Reviewed/Approved By: ______ Date: ______

Reviewed/Approved By: ______ Date: ______

Form 34731 (10-81)
(Formerly SPD-1002-1)

DUKE POWER COMPANY
PROCEDURE PREPARATION
PROCESS RECORD

(1) ID No: PT/0/A/4150/11A
Change(s) 0 to
0 Incorporated

(2) STATION: McGuire

(3) PROCEDURE TITLE: Control Rod Worth Measurement: Rod Swap

(4) PREPARED BY: Michael S. Kitlan Jr DATE: 4/4/84

(5) REVIEWED BY: ____________ DATE: ____________

Cross-Disciplinary Review By: ____________ N/R: ____________

(6) TEMPORARY APPROVAL (IF NECESSARY):

By: ____________ (SRO) Date: ____________

By: ____________ Date: ____________

(7) APPROVED BY: ____________ Date: ____________

(8) MISCELLANEOUS:

Reviewed/Approved By: ____________ Date: ____________

Reviewed/Approved By: ____________ Date: ____________

Form 34634 (4-81) SPD-1001-2

DUKE POWER COMPANY
NUCLEAR SAFETY EVALUATION CHECK LIST

(1) STATION: McGuire UNIT: 1 x 2 x 3 ____
OTHER:

(2) CHECK LIST APPLICABLE TO: ~~PT/0/A/4150/20~~ PT/0/A/4150/11 A
MSK

(3) SAFETY EVALUATION - PART A

The item to which this evaluation is applicable represents:

Yes ____ No X A change to the station or procedures as described in the FSAR or a test or experiment not described in the FSAR?

If the answer to the above is "Yes", attach a detailed description of the item being evaluated and an identification of the affected section(s) of the FSAR.

(4) SAFETY EVALUATION - PART B

Yes ____ No X Will this item require a change to the station Technical Specifications?

If the answer to the above is "Yes," identify the specification(s) affected and/or attach the applicable pages(s) with the change(s) indicated.

(5) SAFETY EVALUATION - PART C

As a result of the item to which this evaluation is applicable:

Yes ____ No X Will the probability of an accident previously evaluated in the FSAR be increased?

Yes ____ No X Will the consequences of an accident previously evaluated in the FSAR be increased?

Yes ____ No X May the possibility of an accident which is different than any already evaluated in the FSAR be created?

Yes ____ No X Will the probability of a malfunction of equipment important to safety previously evaluated in the FSAR be increased?

Yes ____ No X Will the consequences of a malfunction of equipment important to safety previously evaluated in the FSAR be increased?

Yes ____ No X May the possibility of malfunction of equipment important to safety different than any already evaluated in the FSAR be created?

Yes ____ No X Will the margin of safety as defined in the bases to any Technical Specification be reduced?

If the answer to any of the preceding is "Yes", an unreviewed safety question is involved. Justify the conclusion that an unreviewed safety question is or is not involved. Attach additional pages as necessary.

(6) PREPARED BY: Michael S. Kitlan DATE: 4/4/84

(7) REVIEWED BY: ____ DATE: ____

(8) Page 1 of 1

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
CONTROL ROD WORTH MEASUREMENT:
ROD SWAP

1.0 Purpose

1.1 To verify that the reactivity worth of the Reference RCC bank, as determined through reactivity computer measurement data, is consistent with design predictions.

NOTE: The reference RCC bank is the bank which has the predicted highest reactivity worth of all control and shutdown banks when inserted into an otherwise unrodded core.

1.2 To verify that the reactivity worth of each control and shutdown bank (except the reference bank), as inferred from data following iso-reactivity interchange with the reference bank, is consistent with design predictions.

2.0 References

2.1 Rod Bank Worth Measurements Utilizing Bank Exchange, WCAP-9863-A, May 1982.

2.2 Control Rod Worth Measurement, PT/0/A/4150/11

2.3 Post Refueling Controlling Procedure for Criticality, ZPPT, and Power Escalation Testing, PT/0/A/4150/21

2.4 Technical Specifications 3.4.1.1, 3.10.4, 3.10.3, and 3.10.2.

3.0 Time Required

3.1 8 hours, 1 engineer

4.0 Prerequisite Tests

itial/Date

__/____ 4.1 PT/0/A/4150/10, ARO Boron Endpoint Measurement

5.0 Test Equipment

5.1 Reactivity Computer (with flux signal from top and bottom of one power range channel).

5.2 Two two-pen strip chart recorders. One chart recorder should have reactivity (on a scale of 10 pcm/inch, with 0 pcm being the center of the recorder sheet), and T_{avg} from one loop (on a scale of 1°F/inch for 556 to 558°F set up on one side of the recorder sheet). The other chart recorder should have flux (on a scale of 0 to the top end of the testing decade in amps) and pressurizer level (on a scale of 10% level/inch). Chart speeds should be 1 inch/min.

NOTE: The specifications in this step may be altered by the Test Coordinator as necessary to accommodate equipment limitations, as long as all four signals are recorded or trended.

6.0 Limits and Precautions

6.1 The NC system temperature is controlled preferably by steam dump to the condenser. Temperature control may alternatively be affected by steam generator blowdown.

6.2 Normally all reactor coolant pumps should be operating for maximum mixing in the NCS. If all reactor coolant pumps are not operating, the operating pumps should be those on the NCS charging loops (A and/or D). See Tech Spec 3.4.1.1 and 3.10.4 if all reactor coolant pumps are not operating.

6.3 The rod insertion limit and bank overlap sequence will be violated during this test. The operators should be made aware in advance and should anticipate the associated alarms. Technical Specification 3.10.2 and 3.10.3 allows for this.

6.4 Maintain the flux level in the zero power test range established in Reference 2.4.

6.5 Prior to switching the rod control selector switch from one bank to another, verify both groups of the bank (if the bank has two groups) are at the same position in order to avoid group misalignment.

7.0 Required Unit Status

Initial/Date

____/____ 7.1 The unit is just critical in the Startup Mode (Mode 2) at zero power with the flux level in the zero power test range established in PT/0/A/4150/21, "Post Refueling Controlling Procedure for Criticality, ZPPT, and Power Escalation Testing."

____/____ 7.2 Record in the log the unit to which this test applies.

8.0 Prerequisite System Conditions

NOTE: The following steps may be signed off in any order.

____/____ 8.1 The reactor coolant system temperature is 557°F +1, -5°F.

NOTE: Maintain NCS temperature within ±1°F of established temperature during the test.

____/____ 8.2 The difference between NC loop, pressurizer, and VCT boron concentrations is less than 20 ppm. List on Enclosure 13.3.

NOTE: Do not use the boronometer.

____/____ 8.3 Xenon worth rate is changing less than ±.1 pcm/min.

____/____ 8.4 Test equipment is set up per Section 5.0.

____/____ 8.5 All available pressurizer heaters are on as needed, in order to improve mixing by maximizing the pressurizer spray.

____/____ 8.6 All control and shutdown banks are fully withdrawn except Control Bank D which is at a position greater than about 215 steps withdrawn.

____/____ 8.7 The Rod Control Selector switch is in Bank Select Mode set on Control Bank D.

____/____ 8.8 Complete Enclosure 13.1 with the predicted data. See Enclosure 13.9 for an explanation of nomenclature used in this test.

____/____ 8.9 Trend the points listed in Enclosure 13.2 every 15 minutes or less on the OAC.

9.0 Test Method

The RCC bank with the highest predicted value of reactivity worth is measured using the dilution technique per PT/0/A/4150/11. This bank serves as a reference. The integral worth of the remaining RCC banks is implied from the difference in the critical rod position of the reference bank with and without the insertion of bank being tested. The implied integral worths are then compared to predicted rod worths.

10.0 Data Required

10.1 The following conditions for the approximate time of criticality before and after each bank exchange, recorded on Enclosure 13.5:

Time

NCS Tavg

NCS Boron Concentration

Just critical height of reference bank

10.2 Nuclear design predictions on Enclosure 13.1.

10.3 Boron concentration information for the NCS and pressurizer on Enclosure 13.3.

10.4 A copy of the rod positions and rod worths for the reference bank from Enclosure 13.1 of PT/0/A/4150/11 when this test is complete.

10.5 The calculated, implied integral worth (W_x^I) for each RCC bank except the reference bank. List data on Enclosure 13.7.

10.6 The percent difference between inferred and predicted worths for each individual RCC banks (ε_1) and for the sum of all banks (ε_2) on Enclosure 13.8.

11.0 Acceptance Criteria

11.1 The absolute value of the percent difference between measured and predicted integral worth for the reference bank is ≦15% (from Enclosure 13.8 $(\varepsilon_1)_1$ ≦15%).

11.2 From Enclosure 13.8, the calculated value ε_2 ≦10%.

11.3 For all RCC banks other than the reference bank; either:

a) From Enclosure 13.8, ε_{1_x} ≦30% for each bank or

b) $W_x^I - W_x^P$ ≦200 pcm for each bank, whichever is greater.

12.0 Procedure

Initial/Date

NOTE: See Enclosure 13.9 for an explanation of all nomenclature used in this test.

____/____ 12.1 Request NCS and Pressurizer samples to be taken at approximately 15-20 minute intervals until all banks are measured.

NOTE: The Boronometer may not be used for NC loop concentrations.

NOTE: Notify Chemistry that the unused portions of the samples should be retained in appropriately labeled containers, for possible future re-analysis, until all acceptance criteria are met or as specified by the test coordinator.

12.2 Measure the integral reactivity worth of the reference bank as follows:

NOTE: The reference bank is defined as that bank which is predicted to have the highest worth, of all control and shutdown banks, when inserted into an otherwise un-rodded core (see Enclosure 13.1 for the identity of this bank). In this procedure, the banks will be referred to by the bank number, the reference bank being number 1. If the reference bank is currently positioned at less than 228 steps withdrawn (i.e., if it is Control Bank D), continue with step 12.2.5. Mark steps 12.2.1 to 12.2.4 NA. If the reference bank is positioned at 228 steps withdrawn, continue on at Step 12.2.1.

____/____ 12.2.1 Insert the reference bank 1 until the indicated reactivity is approximately -10 pcm.

____/____ 12.2.2 Withdraw the bank inserted below 228 until the indicated reactivity is approximately +10 pcm.

____/____ 12.2.3 Repeat steps 12.2.1 and 12.2.2 until the previously inserted bank is fully withdrawn.

____/____ 12.2.4 Adjust the position of the reference bank 1 until the reactor is just critical. Record this position in the test log.

____/____ 12.2.5 Perform Control Rod Worth Measurement per PT/0/A/4150/11 on the reference Bank 1.

____/____ 12.2.6 Attach a completed copy of PT/0/A/4150/11 Enclosure 13.1 to this procedure.

____/____ 12.2.7 Record the total reference bank rod worth from PT/0/A/4150/11 Enclosure 13.1 on Enclosure 13.7 and 13.8 as shown.

____/____ 12.2.8 Ensure the reactor is critical at the same reference bank position as was obtained at the end of PT/0/A/4150/11.

12.4 Measure the reactivity worth of the remaining control and shutdown banks, relative to the reference Bank 1, as follows:

NOTE: The relative worth of each RCC bank is obtained from the critical position of the reference bank (initially nearly fully inserted) after full insertion of the bank being measured (initially fully withdrawn), at constant RCS boron concentration.

NOTE: Perform rod swap measurements on Control Bank D last if possible.

____/____ 12.4.1 Record the initial critical bank configuration on Enclosure 13.4 and 13.5 for the reference bank. Also record the initial NC boron concentration and average T_{avg} on Enclosure 13.5.

(√) ___ ___ ___ ___ ___
3 4 5 6 7

___ ___
8 9

____/____ 12.4.2 Insert bank 2 (identify this bank on top of Enclosure 13.5; i.e., Bank 2 is S/D E or Cont. B, etc.) until the reactivity indicated by the reactivity computer is approximately -20 pcm.

(√) ___ ___ ___ ___ ___
3 4 5 6 7

___ ___
8 9

____/____ 12.4.3 Withdraw the reference Bank 1 until the indicated reactivity is approximately +20 pcm.

NOTE: Maintain the flux within the zero power test range established in Reference 2.4.

(√) ___ ___ ___ ___ ___
3 4 5 6 7

___ ___
8 9

____/____ (√) ___ ___ ___ ___ ___ (3 4 5 6 7) ___ ___ (8 9)

12.4.4 Repeat Steps 12.4.2 and 12.4.3 until bank 2 is fully inserted. Keep the indicated reactivity within ±20 pcm.

____/____ (√) ___ ___ ___ ___ ___ (3 4 5 6 7) ___ ___ (8 9)

12.4.5 Adjust the position of reference bank 1 until the reactor is just critical. Record the final critical configuration data on Enclosure 13.5. Also record the final NC Boron Concentration and average T_{avg} on Enclosure 13.5.

<u>NOTE</u>: If time permits, measure the differential reactivity worth of reference Bank 1 with the reactivity computer by sequential bank insertions and withdrawals around the critical position. Record information in the test log if this is performed. (Analysis may be performed at a later time.)

____/____ (√) ___ ___ ___ ___ ___ (3 4 5 6 7) ___ ___ (8 9)

12.4.6 Insert the reference Bank 1 until the indicated reactivity is approximately -20 pcm.

____/____ (√) ___ ___ ___ ___ ___ (3 4 5 6 7) ___ ___ (8 9)

12.4.7 Withdraw bank 2 until the indicated reactivity is approximately +20 pcm.

____/____ (√) ___ ___ ___ ___ ___ (3 4 5 6 7) ___ ___ (8 9)

12.4.8 Repeat Steps 12.4.6 and 12.4.7 until bank 2 is fully withdrawn.

____/____ (√) ___ ___ ___ ___ ___ (3 4 5 6 7) ___ ___ (8 9)

12.4.9 Adjust the position of reference Bank 1 until the reactor is just critical. Record the critical configuration data on Enclosures 13.4 and 13.5.

/____ 12.4.10 Repeat Steps 12.4.2 through 12.4.9 for the remaining, unmeasured control and shutdown banks numbered 3 through 9 instead of bank 2. The banks may be measured in any order except that Control Bank D should be measured last. Identify the bank beside the bank number on Enclosures 13.4, 13.6, 13.7 and 13.8.

NOTE: If a Control Bank D-in ITC measurement is to be made, perform Steps 12.5, 12.5.1 and 12.5.2. If not, proceed directly to Step 12.5.3 and mark Steps 12.5, 12.5.1 and 12.5.2 as N/A.

__/____ 12.5 After all rod measurements have been made, again swap Control Bank D for the reference bank 1.

__/____ 12.5.1 By NC Boron Adjustment, reposition Control Bank D and the reference Bank 1 such that Control Bank D is almost fully inserted into the core and the reference bank 1 fully withdrawn from the core. (It is acceptable to have Control Bank D fully inserted and the reference bank 1 almost fully withdrawn.)

/____ 12.5.2 Perform PT/0/A/4150/12B, Moderator Temperature Coefficient of Reactivity During Startup Mode.

__/____ 12.5.3 By NC boron adjustment, reposition control and shutdown banks to the desired normal operating configuration of Control Bank D at about 215 steps withdrawn. Do not go out of Bank Control.

12.6 Perform the following steps once Control Bank D is about 215 steps withdrawn.

___/____ 12.6.1 Go to the Master Cycler Cabinet and reset the Bank Overlap Digital Counter to 000 by pushing the reset button.

___/____ 12.6.2 Reset the Bank Overlap Counter to 345 plus the present Control Bank D position by pushing the button to count up from 000 to the desired value (one push of the button is one digit change on the display).

____/____ 12.6.3 Place rod control to manual.

NOTE: This completes the data acquisition section of this test.

__/____ 12.7 If boron samples are no longer needed to be gathered, notify Chemistry.

___ 12.8 Compute the average reference bank critical position on Enclosure 13.4.

12.9 Compute the inferred worth for each control and shutdown bank (except the reference bank 1) as follows:

___/___ 12.9.1 Using the data from Enclosure 13.4, and the worth measurement data for the reference bank from Enclosure 13.1 of PT/0/A/4150/11, compute the value of $(\Delta\rho_1)_x$ as described below.

$$(\Delta\rho_1)_x = \left[w_R^M \right]_o^{(h_x^M)_o \text{ avg}}$$

where:

$\left[w_R^M \right]_o^{(h_x^M)_o \text{ avg}}$ is the measured integral worth of the reference bank from 0 steps to $(h_x^M)_o$ avg from Enclosure 13.1 of PT/0/A/4150/11.

and $(h_x^M)_o$ avg is the average of the initial and return critical positions of the reference bank before and after interchange with bank x as given on Enclosure 13.4.

Fill in all blanks and complete the calculations on Enclosure 13.4 in the appropriate column.

_/___ 12.9.2 Using the data from Enclosure 13.5, the worth measurement data for the reference bank from Enclosure 13.1 of PT/0/A/4150/11 and the design data of Enclosure 13.1, compute the value of $\alpha_x\ (\Delta\rho_2)_x$ as described below:

$$\alpha_x(\Delta\rho_2)_x = \alpha_x \left[W_R^M \right]_{h_x^M}^{228}$$

where: $\left[W_R^M \right]_{h_x^M}^{228}$ is the measured integral worth of the reference bank from h_x^M to the fully withdrawn position from PT/0/A/4150/11, Enclosure 13.1.

h_x^M is the measured critical position of the reference bank after interchange with bank x from Enclosure 13.5.

and

α_x is a correction factor from Enclosure 13.1 to account for the influence of bank x on the worth of the reference bank.

Fill in all blanks and complete the calculations on Enclosure 13.6.

___/___ 12.9.3 Compute the inferred integral worth of each bank x, W_x^I, as indicated on Enclosure 13.7.

/____ 12.9.4 Compute the percent difference between inferred and predicted worths for each individual RCC bank and the sum of all banks described below.

$$(\varepsilon_1)_x = \left[\frac{W_x^I - W_x^P}{W_x^P}\right] \times 100, \text{ in } \%$$

$$\varepsilon_2 = \left[\frac{\sum_{i=1}^{N} W_i^I - \sum_{i=1}^{N} W_i^P}{\sum_{i=1}^{N} W_i^P}\right] \times 100, \text{ in } \%$$

Fill in all blanks and summarize the calculations on Enclosure 13.8.

__/____ 12.10 Verify all acceptance criteria have been met.

__/____ 12.11 Inform Chemistry to discard the Chemistry samples they have saved, once all results of this test are acceptable.

13.0 Enclosures

13.1 Nuclear Design Predictions for Rod Interchange Measurements

13.2 PAO Data

13.3 Log of Boron Concentrations

13.4 Calculation of $(\Delta\rho_1)x$

13.5 Critical Configuration Data

13.6 Calculation of $\alpha_x(\Delta\rho_2)x$

13.7 Calculation of Inferred Integral Bank Worths

13.8 Comparison of Inferred Bank Worths with Design Predictions

13.9 Nomenclature

Control Rod Worth Measurement: Rod Swap
Enclosure 13.1
Nuclear Design Predictions
for Rod Interchange Measurements

McGuire Unit _____ Cycle _____

Bank No. (x)	Bank Identity +	W_x^P (pcm)	(b) h_x^P (steps)	(c) α_x
(a) 1 (Reference)				
2				
3				
4				
5				
6				
7				
8				
9				

(a) Reference bank - the bank with the highest predicted integral worth.

(b) Reference bank critical position after interchange with bank x.

(c) Ratio of integral worth of the reference bank from h_x^P to the fully withdrawn position with and without x in the core.

\+ Control Bank C, Shut-down Bank E, etc.

NOTE: See Enclosure 13.5 for a complete listing of nomenclature used in this test.

Recorded By ____________________ Date ____________________
This data came from (list source): ____________________
____

Control Rod Worth Measurement: Rod Swap
Enclosure 13.2
PAO Data

A0821	Boric Acid Makeup Blended Flow
P1390	Control Bank A Position
P1391	Control Bank B Position
P1392	Control Bank C Position
P1393	Control Bank D Position
P1546	Shtudown Bank A Position
P1547	Shutdown Bank B Position
P1548	Shutdown Bank C Position
P1549	Shutdown Bank D Position
P1550	Shutdown Bank E Position
A0632	Intermediate Range Channel N35
A0633	Intermediate Range Channel N36
A0819	Loop A T_{avg}
A0825	Loop B T_{avg}
A0831	Loop C T_{avg}
A0837	Loop D T_{avg}
A1058	Loop A ΔT
A1070	Loop B ΔT
A1082	Loop C ΔT
A1094	Loop D ΔT
A1118	Pressurizer Pressure
A0602	Boronometer
A1124	Pressurizer Level
P1461	NC Avg. T_{avg}
P0828	Avg. Incore T/C Temperature
A0603	Boric Acid Flow to Blender
A1064	NC Loop A NR Cold Leg Temperature
A1076	NC Loop B NR Cold Leg Temperature
A1088	NC Loop C NR Cold Leg Temperature
A1100	NC Loop D NR Cold Leg Temperature

Control Rod Worth Measurement: Rod Swap
Enclosure 13.3
Log of Boron Concentrations

Date	Time Sample Taken	NCS Boron Concentrations			Comments	Recorded By
		+VCT	NCS	Press.		

McGuire Unit ___________
Cycle _____

NOTE: VCT sample needed only once at start of the test. Mark this block as N/A after this.

Control Rod Worth Measurement: Rod Swap
Enclosure 13.4
Calculation of $(\Delta\rho_1)_x$

Unit _____ Cycle _____

Date ______________

Bank (x)		$(h^M_x)_o$ (steps)			++ $(\Delta\rho_1)_x$
No.	Ident.	+Initial	*Return	**Average	(pcm)
2					
3					
4					
5					
6					
7					
8					
9					

+Step 12.4.1 - reference bank initial critical position.

*Step 12.4.9 - reference bank final critical position upon exchange with bank x (bank x if out of core).

++Step 12.9.1 **Step 12.8

Recorded By ______________________

____

Control Rod Worth Measurement: Rod Swap
Enclosure 13.5
Critical Configuration Data

nit ______
ycle ______
ate ______________

Time (hrs.)	NC T_{avg} (°F)	NC Boron Conc. (ppm)	Reference Bank Position (steps) $(h_x^M)_o$	(h_x^M)	RCC Bank Positions No. 2 ( )	No. 3 ( )	No. 4 ( )	No. 5 ( )	No. 6 ( )	No. 7 ( )	No. 8 ( )	No. 9 ( )
			+	N/A	228	228	228	228	228	228	228	228
			N/A	*	0	228	228	228	228	228	228	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	0	228	228	228	228	228	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	228	0	228	228	228	228	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	228	228	0	228	228	228	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	228	228	228	0	228	228	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	228	228	228	228	0	228	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	228	228	228	228	228	0	228
			**	N/A	228	228	228	228	228	228	228	228
			N/A	*	228	228	228	228	228	228	228	0
			**	N/A	228	228	228	228	228	228	228	228

Step 12.4.1 - initial critical bank position *Step 12.4.5 - final critical bank position **Step 12.4.9

ecorded By ______________________

Control Rod Worth Measurement: Rod Swap
Enclosure 13.6
Calculation of $\alpha_x(\Delta\rho_2)_x$

Unit _____ Cycle _____

Date ____________________

			(1)	(2)	(1) x (2)
Bank (x)		$^{+}h_x^M$	$\left[W_R^M\right]^{228}_{h_x^M}$	$^{*}\alpha_x$	$\alpha_x(\Delta\rho_2)_x$
No.	Ident.	steps	(pcm)		(pcm)
2					
3					
4					
5					
6					
7					
8					
9					

+from Enclosure 13.5

*from Enclosure 13.1

Recorded By ____________________

____

Control Rod Worth Measurement: Rod Swap
Enclosure 13.7
Calculation of Inferred Integral Bank Worths

Unit _____ Cycle _____ Step 12.2.7 W_R^M = _________ pcm
Date ________________

Bank (x)		+ $(\Delta\rho_1)_x$	* $\alpha_x(\Delta\rho_2)_x$	W_x^I (a)
No.	Ident.	(pcm)	(pcm)	(pcm)
2				
3				
4				
5				
6				
7				
8				
9				

(a) $W^I = W_R^M - (\Delta\rho_1)_x - \alpha_x(\Delta\rho_2)_x$

+from Enclosure 13.4

*from Enclosure 13.6

Recorded by ______________________

Control Rod Worth Measurement: Rod Swap
Enclosure 13.8
Comparison of Inferred Bank Worths
With Design Predictions

Unit ____ Cycle ____
Date ________

Bank (x)		++ W_x^I	* W_x^P	$(\varepsilon_1)_x$
No.	Ident.	(pcm)	(pcm)	(%)
1 reference		+		
2				
3				
4				
5				
6				
7				
8				
9				

$\sum W_x^I$ (pcm)	$\sum W_x^P$ (pcm)	ε_2 (%)

+Step 12.2.7: Record the measured worth of the reference bank here.

*from Enclosure 13.1

++from Enclosure 13.7

Recorded By ________________

____

DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

March 11, 1987

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: McGuire Nuclear Station
Docket Nos. 50-369/370
Catawba Nuclear Station
Docket Nos. 50-413/414
Determination of Rod Worth Using
Rod Swap Methodology

Gentlemen:

Pursuant to telecons of February 19, 1987 and March 10, 1987 between D.S. Hood (ONRR) et. al., and S.A. Gewehr (DPC) et. al., attached are revised responses to Questions 6 and 7 of D.S. Hood's request for information dated January 12, 1987.

Very truly yours,

H.B. Tucker / [illegible]

Hal B. Tucker

SAG/61/jgm

Attachment

A001
1/1

QUESTION 6: Provide data for at least 2 sets of side-by-side comparisons of Boron dilution and Rod Swap Data - predicted and measured. The data may be either for your plants or measured data from another plant and predictions by Duke.

RESPONSE:

In the original Nuclear Physics Methodology Topical, DPC-NF-2010A, Duke Power Company benchmarked its methods for predicting rod worths against measurements made during the startup testing for both initial cores at the McGuire Nuclear Station. These measurements were made using the boration/ dilution technique for determining rod worths in sequential insertion. In its review of this topical, the NRC accepted the capability of Duke Power to adequately predict control rod worths and shutdown margin using the outlined methodology.

In the Rod Swap Methodology Report recently sent to the Commission, Duke Power benchmarked its methodology for predicting rod worths using the rod swap technique against 5 cycles of actual rod swap measurements. This methodology utilized the same computer codes previously benchmarked in DPC-NF-2010A. All predictions, when compared to the measured results, met the acceptance criteria as outlined in the rod swap plant procedure.

It has been noted in previous conversations with the NRC that the two benchmarking studies noted above do not make comparisons of the same units for the same cycles. It is Duke Power's position that there is really no benefit from this type of comparison. A valid comparison cannot be expected since boration/-dilution is a sequential measured worth calculation and rod swap consists of a summation of the worths of each rod individually inserted into an otherwise unrodded core. It is therefore impossible to make direct comparisons between worths of the two methods. The only thing that can be looked at is the percent difference between measured and predicted for th two methods. When looking at percent differences between measured and predicted, one does not have to look at the same unit and cycle to verify methodologies are correct. Comparisons of predicted and measured rod worths done using boration/ dilution and rod swap on the two Catawba units are enclosed. The boration/dilution technique was used to measure rod worths in sequential bank insertion for the Catawba 1 Cycle 1 core while Catawba 2 Cycle 1 measurements were done using the rod swap technique (Table 1). From a neutronics standpoint, the two cores are almost identical. This assumption can be justified by examining the core loadings and the results of the Zero Power Physics Testing for each of the units. Several key parameters concerning the core are shown in Table 2. Also enclosed are the quarter core loading pattern (Figure 1) and a comparison of the quarter core assembly power distribution from the zero power map taken during the startup physics testing (Figure 2).

It should also be pointed out that the rod worths from the rod swap predictions are not the worths used to calculate the shutdown margin. Rod swap only verifies the code's ability to predict rod worths. The rod worth used in the shutdown margin calculation is the N-1 worth.

Duke Power has provided a total of nine cycle of predicted rod worth comparisons to measured data with good to excellent results. This demonstrates the ability of the codes and methods used to adequately model reactivity effects due to control rods in any configuration. Therefore, the use of Duke Power predictions in the verification of shutdown margin with appropriate factors of conservatism applied to the calculation as outlined in DPC-NF-2010A Section 4.2.2.2 is justified.

QUESTION 7: What Organization does the safety analysis for the Duke Plants? When this is not done by Duke, what is done (e.g. tests, comparisons, etc.) to show that the startup test results adequately represent the plant features and assumptions used in the safety analyses?

RESPONSE:

The safety analyses for the McGuire and Catawba Nuclear Stations have been performed by the current fuel vendor. The analyses utilized NRC-approved codes and methodologies and conservative input assumptions including values for key nuclear physics parameters such as reactivity coefficients, core power distributions, and shutdown margins, which are expected to bound the actual values of these parameters for current and future reload cores. An evaluation is performed for each reload cycle which consists of comparing nuclear design predictions to the safety analyses assumptions to ensure the safety analyses remain bounding. The cycle-specific evaluation process is described in WCAP-9272, "Westinghouse Reload Safety Evaluation Methodology." Core physics testing performed for each cycle verifies the nuclear design predictions and ensures the actual core physics parameters are conservative with respect to the safety analyses.

The main safety analysis assumption verified by the rod swap procedure is that the plant will maintain adequate shutdown margin per Technical Specifications. One of the purposes of rod swap measurements and comparisons to predicted values is to verify the accuracy of the total rod worth prediction used as an input to the shutdown margin calculation. An independent Duke Power shutdown margin is evaluated for each cycle using methods approved by the NRC in DPC-NF-2010A. The N-1 rod worth used in this prediction is reduced by 10% for conservatism. Acceptance criteria listed in the procedure indicate that the total inferred rod worth as measured in the rod swap testing must be within 10% of the total predicted worth. If the total measured rod worth is less than the predicted worth by more than 10%, a review of the shutdown margin is made to determine if the current rod insertion limits provide adequate shutdown margin. If the shutdown margin is adequate. then no revision of the limits is necessary. However, if the margin is not maintained, then Duke will notify Westinghouse, revise the rod insertion limits, and submit any necessary changes to Technical Specifications to the NRC.

In order to tie the rod swap measurements to the verification of inputs to the safety analysis, Duke Power will perform an independent shutdown margin for each reload cycle using methods approved by the NRC in DPC-NF-2010A. In addition, for each cycle where Duke generates the rod swap prediction but the safety analysis has been performed by a vendor, a comparison between the Duke and vendor predicted total rod worth will be made at beginning-of-cycle, hot zero power conditions. Any significant discrepancies will be documented, reviewed, and resolved prior to startup physics testing.

Reference

McGuire Nuclear Station, Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testing, DPC-NE-1003, Rev. 1, December 1986.

TABLE 1

Rod Worth Measurement Data
Comparison of Rod Swap and Boration/Dilution Techniques

Bank	Rod Swap Integral Worths			Boron/Dilution Integral Worths		
	Predicted (PCM)	Measured (PCM)	% Diff**	Predicted (PCM)	Measured (PCM)	% Diff**
D	772	794	-2.85	773	788	-1.94
C	790	849	-7.47	1214	1203	0.91
B*	852	882	-3.52	1190	1171	1.60
A	249	250	-0.40	572	548	4.20
SE	377	385	-2.12	508	460	9.45
SD	497	525	-5.63	755	772	-2.25
SC	497	522	-5.03	1098	1099	-0.09
SB	765	834	-9.02	-	-	-
SA	674	706	-4.75	-	-	-
N-1	-	-	-	7370	7414	-.60
N	5473	5747	-5.01			

* Reference Bank

** % Diff = [(P-M)/P]*100

TABLE 2

Catawba 1 Cycle 1 and Catawba 2 Cycle 1
Comparison of Core Parameters

	Unit 1	Unit 2
KG U/ASSY		
Batch 1 1.6	424.169	424.623
Batch 2 2.4	423.508	425.805
Batch 3 3.1	423.676	424.519
AVE ENR		
Batch 1	1.6101	1.6104
Batch 2	2.3999	2.4014
Batch 3	3.1022	3.0954
ARO BORON ENDPOINT (PPMB)	975	975
ISO. TEMP. COEFF (PCM/°F)	-1.745	-1.81

Figure 1

CATAWBA 1 CYCLE 1 AND CATAWBA 2 CYCLE 1
QUARTER CORE LOADING PATTERN

	H	G	F	E	D	C	B	A
8	1.60	2.40 16	1.60	2.40 12	1.60	2.40 16	1.60	3.10 6
9	2.40 16	1.60	2.40 12	1.60	2.40 12	1.60	3.10 20	3.10
10	1.60	2.40 12	1.60	2.40 12	1.60	2.40 16	1.60	3.10 6
11	2.40 12	1.60	2.40 12	1.60	2.40 16	1.60	3.10 16	3.10
12	1.60	2.40 12	1.60	2.40 16	2.40	2.40 16	3.10	
13	2.40 16	1.60	2.40 16	1.60	2.40 16	3.10 15	3.10	
14	1.60	3.10 20	1.60	3.10 16	3.10	3.10	ENRICHMENT NUMBER OF BA'S PER ASSY	
15	3.10 6	3.10	3.10 6	3.10				

Figure 2

C1C1 AND C2C1 HZP POWER DISTRIBUTIONS 0 MWD/MTU

ARO, HZP, NO XE, NO SM

	H	G	F	E	D	C	B	A	
	.72	.82	.84	1.00	.89	.97	.95	.97	
8	.72	.82	.82	.97	.87	.94	.93	.95	
	0.00	0.00	2.44	3.09	2.30	3.19	2.15	2.11	
	.82	.79	.95	.88	1.02	.91	1.11	1.01	
9	.82	.78	.95	.88	1.01	.89	1.10	1.00	
	0.00	1.28	0.00	0.00	.99	2.25	.91	1.00	
	.83	.96	.89	1.04	.93	1.01	.93	.90	
10	.83	.95	.89	1.05	.93	1.01	.93	.89	
	0.00	1.05	0.00	-.95	0.00	0.00	0.00	1.12	
	1.01	.90	1.06	.99	1.12	1.03	1.16	.73	
11	1.00	.89	1.06	.99	1.12	1.03	1.17	.74	
	1.00	1.12	0.00	0.00	0.00	0.00	-.85	-1.35	
	.91	1.04	.94	1.12	1.43	1.19	1.22		
12	.91	1.04	.93	1.13	1.44	1.19	1.23		
	0.00	0.00	1.08	-.88	-.69	0.00	-.81		
	.98	.92	1.03	1.04	1.19	1.22	.89		
13	1.01	.94	1.04	1.06	1.20	1.21	.88		
	-2.97	-2.13	-.96	-1.89	-.83	.83	1.14		
	.97	1.14	.96	1.18	1.22	.88			
14	.98	1.16	.97	1.19	1.22	.89			
	-1.02	-1.72	-1.03	-.84	0.00	-1.12			
	1.00	1.04	.92	.74	C1C1				
15	1.00	1.04	.93	.76	C2C1				
	0.00	0.00	-1.08	-2.63	% DIFF				

C1C1 CORE AVERAGE 1.00
C2C1 CORE AVERAGE 1.00
% DIFF CORE AVERAGE -.05

C1C1 MAXIMUM MAGNITUDE IS 1.43 AT ASSEMBLY D - 12
C2C1 MAXIMUM MAGNITUDE IS 1.44 AT ASSEMBLY D - 12
% DIFF MAXIMUM MAGNITUDE IS 3.19 AT ASSEMBLY C - 8
PERCENT ERROR BETWEEN THE MAXIMUM VALUES IS -.69

AVERAGE ABSOLUTE RELATIVE ERROR .88 PERCENT
ROOT MEAN SQUARE OF THE RELATIVE ERROR 1.22 PERCENT
ROOT MEAN SQUARE OF THE DIFFERENCE 1.16 PERCENT

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 26, 2002

Mr. M. S. Tuckman
Executive Vice President
Nuclear Generation
Duke Energy Corporation
526 South Church St
Charlottte, NC 28202

SUBJECT: CATAWBA NUCLEAR STATION, UNITS 1 AND 2 AND MCGUIRE NUCLEAR STATION, UNITS 1 AND 2 RE: REQUEST FOR ADDITIONAL INFORMATION - APPLICATION FOR CHANGES TO TECHNICAL SPECIFICATIONS (TAC NOS. MB3343, MB3344, MB3222 AND MB3223)

Dear Mr. Tuckman:

The Nuclear Regulatory Commission is reviewing your application dated October 7, 2001, entitled "License Amendment Request applicable to Technical Specifications 5.6.5, Core Operating Limits Report; Revisions to Bases 3.2.1 and 3.2.3; and Revisions to Topical Reports DPC-NE-2009-P, DPC-NF-2010, DPC-NE-2011-P, and DPC-NE-1003" and has identified a need for additional information as identified in the Enclosure. These issues were discussed with your staff on June 6, 2002. Please provide a response to this request within forty-five (45) days of receipt of this letter so that we may complete our review.

Sincerely,

Robert Martin

Robert E. Martin, Senior Project Manager, Section 1
Project Directorate
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-413, 50-414, 50-369 and 50-370

Enclosure: Request for Additional Information

cc w/encl: See next page

McGuire Nuclear Station

cc:
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York, South Carolina 29745

REQUEST FOR ADDITIONAL INFORMATION

LICENSE AMENDMENT REQUEST APPLICABLE TO

TECHNICAL SPECIFICATION 5.6.5, CORE OPERATING LIMITS REPORT,

REVISIONS TO BASES 3.2.1 and 3.2.3

REVISIONS TO TOPICAL REPORTS DPC-NE-2009-P,

DPC-NF-2010, DPC-NE-2011-P, AND DPC-NE-1003

CATAWBA NUCLEAR STATION, UNITS 1 AND 2

MCGUIRE NUCLEAR STATION, UNITS 1 and 2

DUKE ENERGY CORPORATION

Topical Reports Numbered DPC-NE-2009-P Duke Power Company Westinghouse Fuel Transition Report and DPC-NF-2010-A, Duke Power Company McGuire Nuclear Station and Catawba Nuclear Station Nuclear Physics Methodology for Reload Design

1. Please provide a detailed qualitative technical justification for the requested changes to the topical reports (methodologies), DPC-NE-2011 and DPC-NF-2010. (i.e., why are these changes being made?).

2. To expedite the review process, please provide a qualitative and quantitative technical basis for each of the changes in these topical reports.

3. Please provide validation data that bench-marks the results of comparisons between the old and the new models (changes).

4. If the changes to these topical reports and methodologies impact the safe operation of the reactor core, please provide the safety significance (impact) of each of these changes.

5. Please provide the basis for why the proposed changes to the above stated topical reports should be found acceptable.

Topical Report Numbered DPC-NF-2010-A, Duke Power Company McGuire Nuclear Station and Catawba Nuclear Station Nuclear Physics Methodology for Reload Design

1. In the revision history section on page ii, the licensee provides the staff with the reason for the submittal. Since this is a licensing action, please list those Technical Specification(s), Bases, FSAR sections, conformance to regulatory documents, criteria, generic letters, etc. that are impacted by the request for these changes within the licensing framework.

2. Section 4.2.4.2, second paragraph. Please provide clarification of this change and the technical justification for it. Please provide a comparison between the old sentence and the new sentence.

3. In Attachment 7a, "Detailed Listing of the Changes to DPC-NF2010A," it is stated in many places, that "this change is made to avoid difficulties with the literal interpretation of the original description." Please provide clarification of this statement with a supporting example.

4. Section 4.2.4.4, fifth paragraph. Please provide clarification of this change and the technical justification for it. Please provide comparison between the old sentence and the new sentence.

5. Section 8.1, first paragraph. Is the added equation the same as that in the current version of the DPC-NF-2010A topical? If not, please provide technical justification for its use.

6. Section 9.1.5, first paragraph. Please provide clarification of this change and the technical justification for it. Please provide a comparison between the old sentence and the new sentence.

<u>Topical Report Numbered DPC-NE-2011-P-A, Duke Power Company Nuclear Design Methodology Report for Core Operating Limits of Westinghouse Reactors</u>

1. The description of the transient conditions was changed in Tables 1 and 2, of Section 2.5. It is not clear to the staff exactly what was changed. Please clarify.

2. From section 6.1, please explain what is meant by "updated the equation."

3. From section 6.1, please provide further clarification of this statement.

4. Section 6.2, were is UMR listed in section 6.2? Please provide original definition and new definition for comparison.

<u>Topical Report Numbered DPC-NE-1003, Revision 1 McGuire Nuclear Station and Catawba Nuclear Station Rod Swop Methodology Report for Startup Physics Testings, Revision 1</u>

1. Appendix A of topical report DPC-NE-1003, Revision 1, contains two versions of Duke Power Company's rod swap measurement procedure PT/O/A/4150/11A: Attachment 3 (dated June 1986) and Attachment 4 (dated April 1984). There are differences in these two versions of the procedure. For example, in the Attachment 3 version, Steps 12.2.2 and 12.2.3, respectively, specify the insertion of bank 1 until the indicated reactivity is approximately -20 pcm, and the withdrawal of reference bank until the indicated reactivity is approximately +20 pcm; whereas in the Attachment 4 version, the insertion and withdrawal of bank 1 and reference bank, respectively, of steps 12.2.1 and 12.2.2 specify reactivity change of -/+ 10 pcm.

a. Since the Attachment 3 version of procedures is more recent, why is the Attachment 4 version referenced in Revision 1 of the topical report (Reference 2)?

b. Which of these two versions of rod swap measurement procedures will be used for McGuire and Catawba Units?

2. In the Attachment 3 version of rod swap measurement procedures PT/O/A/4150/11A, Step 12.1.3 states that: "Repeat steps 12.2.1 and 12.2.2 until the previously inserted bank is fully withdrawn."

Is there a typographic error in the words "steps 12.2.1 and 12.2.2"? Should correct words be "steps 12.1.1 and 12.1.2"?

3. The equation in Section 3, Measurement Procedure, of the topical report for calculating the inferred rod worth of bank x is different from the equation in Step 12.5.3 of the Attachment 3 procedures. The difference appears to be due to the initial height of the reference bank for performing the rod swap measurement of the measured bank.

Clarify the exact procedure to be used in the rod swap test, and make all necessary corrections in the topical report and the procedures to be consistent.

4. The third sentence in Section 3 of the topical report is revised to read: "All other banks are then exchanged with the reference bank or other test banks at constant boron conditions until the measured bank is fully inserted." It is stated, in Attachment 9a, "Detailed Listing of Changes to DPC-NE-1003A," that the third sentence in Section 3 is revised to make the report consistent with current procedures. The "Revision History" in the topical report states that this revision [Revision 1] also reflects a refinement in the rod swap to make use of two test banks.

a. What are the current procedures? What is the date of the current procedures?

b. Are the current procedures the same or different from the ones in Attachment 3? The Attachment 3 procedures do not include the exchange of a test bank with the other test bank.

c. If the current procedures are different from those of Attachment 3 or 4, provide a copy of the procedures, and appropriately reference them in the report.

d. Is the statement in "Revision History" referring to this revision? Please explain what the statement means.

Duke Power®
A Duke Energy Company

Michael S. Tuckman
Executive Vice President
Nuclear Generation

Duke Energy Corporation
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August 7, 2002

U. S. Nuclear Regulatory Commission
Washington D.C. 20555-0001
ATTENTION: Document Control Desk

Subject: Duke Energy Corporation

McGuire Nuclear Station, Units 1 and 2
Docket Nos. 50-369 and 370

Catawba Nuclear Station, Units 1 and 2
Docket Nos. 50-413 and 414

Response to NRC Request for Additional Information - TAC nos. MB3222, MB3223, MB3343, and MB3344) and License Amendment Request Supplement

This purpose of this letter is to provide Duke Energy Corporation's (Duke) response to an NRC request for additional information (RAI) and to supplement a Duke license amendment request (LAR) previously submitted pursuant to 10CFR50.90. Please note that some of the information contained in this submittal package has been determined to be proprietary and is being submitted pursuant to 10CFR2.790. This proprietary information is discussed below.

Duke submitted[1] a LAR applicable to McGuire and Catawba Technical Specifications (TS) 5.6.5.a and 5.6.5.b. Also included in this submittal were proposed revisions to the four Duke Topical Reports listed below.

---

[1] Reference 1: Letter, Duke Energy Corporation to U.S. Nuclear Regulatory Commission, ATTENTION: Document Control Desk, Dated October 7, 2001, SUBJECT: License Amendment Request Applicable to Technical Specification 5.6.5, Core Operating Limits Report; Revisions to Bases 3.2.1 and 3.2.3; and Revisions to Topical Reports DPC-NE-2009-P, DPC-NF-2010, DPC-NE-2011-P, and DPC-NE-1003

- DPC-NE-2009-P, *Duke Power Company Westinghouse Fuel Transition Report*, Revision 1;
- DPC-NF-2010, *Duke Power Company McGuire Nuclear Station and Catawba Nuclear Station Nuclear Physics Methodology for Reload Design*, Revision 1;
- DPC-NE-2011-P, *Duke Power Company Nuclear Design Methodology Report for Core Operating Limits of Westinghouse Reactors*, Revision 1;
- DPC-NE-1003, McGuire Nuclear Station and Catawba Nuclear Station *Rod Swap Methodology Report for Startup Physics Testing*, Revision 1.

The NRC RAI[2] asked questions on these topical reports. As described below, the Duke responses to these questions are included in the attachments to this letter.

In a subsequent submittal,[3] Duke proposed another LAR for McGuire and Catawba TS 5.6.5, but this LAR was only applicable to TS 5.6.5.b. The information contained herein explains the necessary coordination for changing TS 5.6.5.b for McGuire and Catawba. This LAR implements the provisions of an NRC approved Technical Specifications Task Force (TSTF) Standard Technical Specifications Traveler.[4] The NRC has approved and issued this LAR for both McGuire[5] and Catawba.[6] Implementation of the

---

[2] Reference 2: Letter, U. S. Nuclear Regulatory Commission to Duke Energy Corporation, Dated June 26, 2002, SUBJECT: Request for Additional Information, Application for Changes to Technical Specifications (TAC Nos. MB3222, MB3223, MB3343, and MB3344

[3] Reference 3, Letter, Duke Energy Corporation to U.S. Nuclear Regulatory Commission, ATTENTION: Document Control Desk, Dated December 20, 2001, SUBJECT: License Amendment Request Applicable to the Technical Specifications Requirements for the Core Operating Limits Report – Oconee, McGuire, and Catawba Technical Specification 5.6.5

[4] TSTF-363, "Revise Topical Report References in ITS 5.6.5 COLR"

[5] Letter, U. S. Nuclear Regulatory Commission to Duke Energy Corporation Dated July 10, 2002, SUBJECT: McGuire Nuclear Station, Units 1 and 2 RE: Issuance of Amendments (TAC Nos. MB3702 and MB3703)

[6] Letter, U. S. Nuclear Regulatory Commission to Duke Energy Corporation Dated July 2, 2002, SUBJECT: Catawba Nuclear Station, Units 1 and 2 RE: Issuance of Amendments (TAC Nos. MB3728 and MB3729)

referenced industry traveler eliminates the need for the changes Duke proposed to McGuire and Catawba TS 5.6.5.b in Reference 1. The LAR supplement transmitted herein deletes the proposed changes to McGuire and Catawba TS 5.6.5.b contained in Reference 1. The attached McGuire and Catawba TS pages (both marked and reprinted versions) update Reference 1 such that it contains the latest approved version of the affected TS pages and only applies to McGuire and Catawba TS 5.6.5.a. The affected TS pages are:

McGuire Units 1 and 2 Pages: 5.6-2, 5.6-3, B3.2.1-11, and B3.2.3-4; and

Catawba Units 1 and 2 Pages: 5.6-3, B3.2.1-11, and B3.2.3-4.

As shown, conforming Bases changes have been made and the necessary Bases pages are also included.

The attachments to this letter are listed and described below.

- Attachment 1 provides the Duke response to the NRC's general questions on Topical Reports DPC-NF-2010 and DPC-NE-2011-P.

- Attachment 2 provides the Duke response to the NRC's specific questions on Topical Report DPC-NF-2010.

- Attachments 3a and 3b provide the Duke responses to the NRC's specific questions on Topical Report DPC-NE-2011-P. Attachment 3a is the proprietary version and Attachment 3b is the non-proprietary version.

- Attachment 4 provides the Duke response to the NRC's specific questions on Topical Report DPC-NE-1003.

- Attachment 5 provides the Duke response to an NRC concern on Topical Report DPC-NE-2009-P. This concern was not included in the NRC's RAI,[2] however it was discussed during an NRC/Duke telephone conference held on July 24, 2002.

- Attachments 6a and 6b provide a marked copy of the existing approved Technical Specifications pages for McGuire Units 1 and 2 and Catawba Units 1 and 2, respectively. These marked copies show the proposed changes.

- Attachments 7a and 7b provide the reprinted Technical Specifications and Bases pages for McGuire Units 1 and 2 and Catawba Units 1 and 2, respectively.

Duke has determined that the revisions contained in this LAR supplement, as shown in Attachments 6a, 6b, 7a, and 7b have no impact on the determination of no significant hazards consideration that was included in Reference 1.

This submittal package contains information that Duke considers proprietary. This information is contained within the proprietary version of the response to the NRC questions on Topical Report DPC-NE-2011-P that is provided as Attachment 3a to this letter. In accordance with 10CFR2.790, Duke requests that this information be withheld from public disclosure. An affidavit that attests to the proprietary nature of this information is included with this letter. A non-proprietary version of this response is also provided as Attachment 3b to this letter.

Inquiries on this matter should be directed to J. S. Warren at (704) 382-4986.

Very truly yours,

M. S. Tuckman

M. S. Tuckman

xc w/Attachments:

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South Carolina Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

M. S. Tuckman, affirms that he is the person who subscribed his name to the foregoing statement, and that all the matters and facts set forth herein are true and correct to the best of his knowledge.

M. S. Tuckman

M. S. Tuckman, Executive Vice President

Subscribed and sworn to me: August 7, 2002
Date

Mary P. Nelms, Notary Public

My commission expires: JAN 22, 2006

SEAL

bxc w/Attachments:

M. T. Cash
C. J. Thomas
G. D. Gilbert
L. E. Nicholson
K. L. Crane
K. E. Nicholson
J. M. Ferguson (2) - CN01SA
L. J. Rudy
G. A. Copp
R. L. Gill
P. M. Abraham
G. G. Pihl
D. R. Koontz
R. C. Harvey
MNS Master File - MG01DM
Catawba Master File - CN04DM
NRIA/ELL

Catawba Owners:
Saluda River Electric Corporation
P. O. Box 929
Laurens, SC 29360-0929

NC Municipal Power Agency No. 1
P. O. Box 29513
Raleigh, NC 27626-0513

T. R. Puryear
NC Electric Membership Corporation
CN03G

Piedmont Municipal Power Agency
121 Village Drive
Greer, SC 29651

Attachment 4
Responses to Request for Additional Information
Topical Report Numbered DPC-NE-1003, Revision 1, McGuire Nuclear Station and Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testings (TAC NOS. MB3343, MB3344, MB3222, MB3223)

General

Subsequent to receiving the NRC RAI package, a clarification of Question 4.d. was obtained from the NRC during a conference call on Monday July 15, 2002. Responses to all questions in the NRC RAI are given below, and responses to Question 4.d. takes into account the clarification received from the NRC. Some of the responses require making revisions to the proposed version of this topical report. The revised pages are included at the end of this Attachment.

Question 1. Appendix A of topical report DPC-NE-1003, Revision 1, contains two versions of DPC's rod swap measurement procedures PT/O/A/4150/11A: Attachment 3 (dated June 1986) and Attachment 4 (dated April 1984). There are differences in these two versions of procedures. For example, in the Attachment 3 version, Steps 12.2.2.and 12.2.3, respectively, specify the insertion of bank 1 until the indicated reactivity is approximately -20 pcm, and the withdrawal of reference bank until the indicated reactivity is approximately +20 pcm; whereas in the Attachment 4 version, the insertion and withdrawal of bank 1 and reference bank, respectively, of steps 12.2.1 and 12.2.2 specify reactivity change of -/+ 10 pcm.

a. Since the Attachment 3 version of procedures is more recent, why is the Attachment 4 version referenced in Revision 1 of the topical report (Reference 2)?

b. Which of these two versions of rod swap measurement procedures will be used for McGuire and Catawba Units?

Response 1.a.

Appendix A of the submitted report is labeled "NRC/DPC Correspondence Including DPC Responses to NRC Requests for Additional Information." The information currently in Appendix A contains information provided by DPC in response to the NRC RAI (letter dated 1/12/87) associated with the original submittal of this report. The differences in Attachment 3 and Attachment 4 are due to the timing of the submittals of this topical report, NRC RAI, and DPC responses.

Attachment 3 contains the then most current versions of the procedures for rod swap measurements and were provided in response to Question 2 in the NRC RAI mentioned above. Attachment 4 is an earlier version of the Rod Swap procedure, and this procedure was provided in response to Question 5 of the NRC RAI mentioned above.

The reference list in the proposed version of this topical report was not updated, because the procedure is referenced in a general way and because some of the measured data used to perform the benchmark calculations was processed using the procedure referenced in the original submittal.

Response 1.b.
Duke currently employs the Westinghouse Dynamic Rod Worth Measurement technique for determining rod worth during ZPPT; however, rod swap may be used as a contingency. The procedure to be used in the event the rod swap test is to be performed now is not the same as those shown in Attachments 3 and 4. An information only version of the current procedure is provided in Attachment 4 (see response to Question 4.c.)

Question 2. In the Attachment 3 version of rod swap measurement procedures PT/O/A/4150/11A, Step 12.1.3 states that: "Repeat steps 12.2.1 and 12.2.2 until the previously inserted bank fully withdrawn." Is there a typographic error in the words "steps 12.2.1 and 12.2.2"? Should the correct words appear to be "steps 12.1.1 and 12.1.2"?

Response
Yes, this is a typographical error. This error is not in the current Rod Swap procedure.

Question 3. The equation in Section 3, Measurement Procedure, of the topical report for calculating the inferred rod worth of bank x is different from the equation in Step 12.5.3 of the Attachment 3 procedures. The difference appears to be due to the initial height of the reference bank for performing the rod swap measurement of the measured bank. Clarify the exact procedure to be used in the rod swap test, and make all necessary corrections in the topical report and the procedures to be consistent.

Response
The difference is the initial height of the reference bank for measuring the other banks. In the situation where the reference bank only inserted critical position is 0 SWD, the results of the topical report equation and the procedure equation are the same. If the critical position of the reference bank only inserted is not 0 SWD, it is necessary to account for this small amount of reactivity. This situation may arise as a result of small temperature or boron changes during the test. The proposed topical report has been modified to reflect this, and the revised pages (Pages 2 and 3) are included at the end of this Attachment.

Question 4. The third sentence in Section 3 of the topical report is revised to read: "All other banks are then exchanged with the reference bank or other test banks at constant boron conditions until the measured bank is fully inserted." It is stated, in Attachment 9a - Detailed Listing of Changes to DPC-NE-1003A, that the third sentence in Section 3 is revised to make the report consistent with current procedures. The "Revision History" in the topical report states that this revision [Revision 1] also reflects a refinement in the rod swap to make use of two test banks.

a. What is the "current procedures"? What is the date of the current procedures?
b. Are the current procedures the same or different from the one in Attachment 3? The Attachment 3 procedures did not include the exchange of a test bank with other test bank.
c. If the "current procedures" are different from that of Attachment 3 or 4, provide a copy of the procedures, and appropriately reference it in the report.
d. Is the statement in "Revision History" referring to this revision? Please explain what the statement means.

Response 4.a.
The current McGuire procedure is PT/0/A/4150/11A, dated 1/19/96.

Response 4.b.
The current procedure is not the same as Attachment 3. The current procedure allows for the exchange of two test banks, namely of the bank to be measured and the bank just measured. This exchange takes place while moving the test bank to be measured into the fully inserted position.

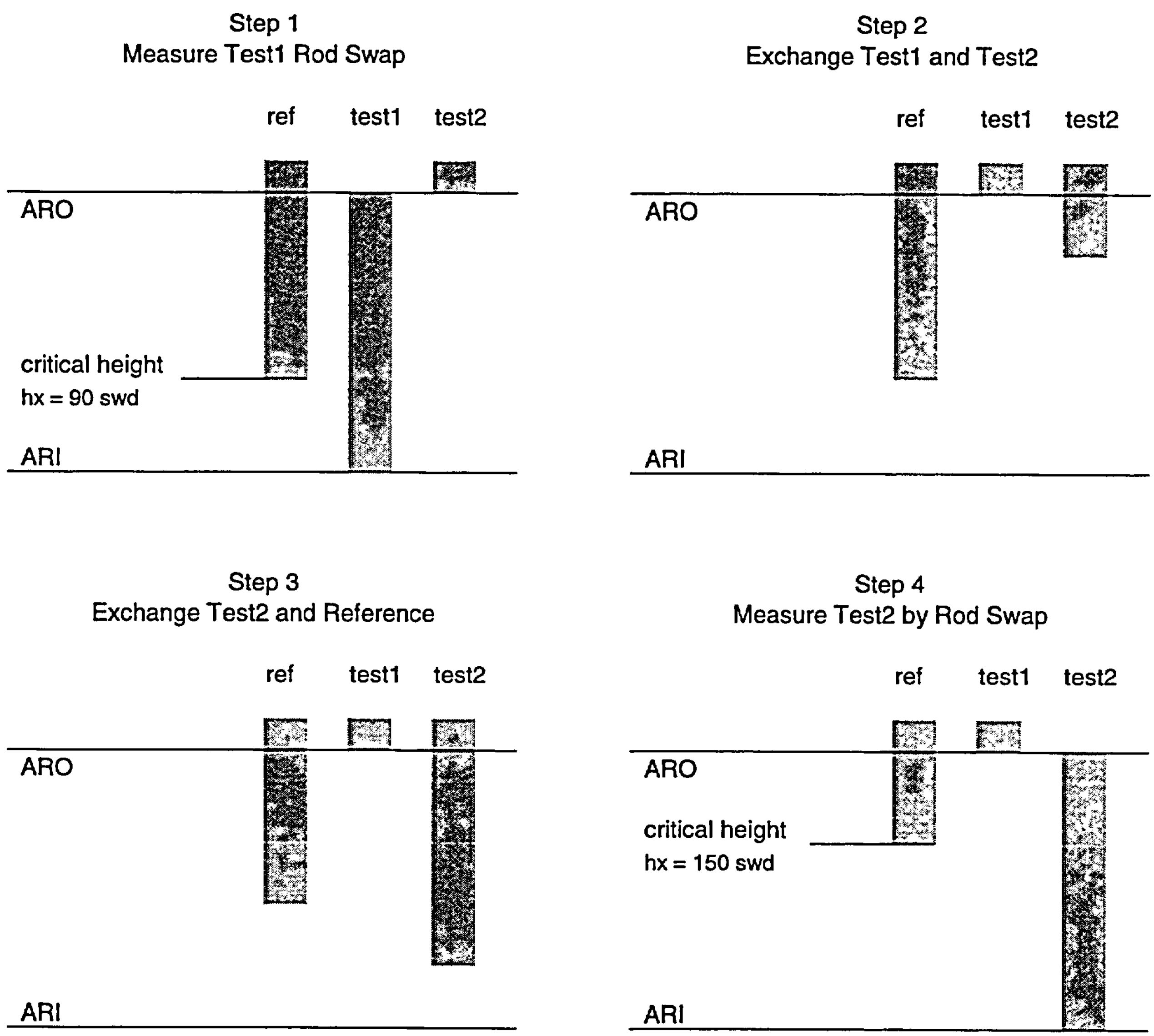
Response 4.c.
An information only copy of the current McGuire procedure is included in Attachment 4 of this response package. The topical report only makes a general reference to the plant procedure.

Response 4.d.
The statement "This revision also reflects a refinement in the rod swap to make use of two test banks." in the Revision History of this topical report does apply to this proposed revision. The statement refers to the description of intermediate steps of exchanging two test banks after measuring the worth of one test bank and before measuring the worth of the next test bank.

The test bank to be measured is moved into the fully inserted position by exchanging first with the previous test bank and then with the reference bank as necessary. The final test bank/reference bank configuration, and therefore measured worth of the test bank, is the same whether it is exchanged with the reference bank or with the previous test bank. This evolution is shown pictorially on the next page.

Clarification of Appendix A
An additional correspondence between DPC and the NRC became known subsequent to the submittal of the proposed version of this topical report. Appendix A of the proposed version of this topical report has been modified to include this additional correspondence. The pages to be added to Appendix A are provided at the end of Attachment 4

Rod Swap
Rod Exchange with Two Test Banks



Attachment 4
Responses to Request for Additional Information
Topical Report Numbered DPC-NE-1003, Revision 1, McGuire Nuclear Station and Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testings
(TAC NOS. MB3343, MB3344, MB3222, MB3223)

The following pages of this Attachment contain the marked up and reprinted pages that are revised from the proposed version of this topical report. These pages are being provided in response to Question 3.

2. Definitions

The following is a list of the constants needed by the plant, to perform the rod swap procedure. These include:

- W^P_x - Predicted reactivity worth of each control and shutdown bank, when inserted individually into an otherwise unrodded core.

- h^P_x - Predicted critical position of the reference bank after interchange with bank x, starting with the reference bank at 0 steps and bank x fully withdrawn.

- α_x - A correction factor which accounts for the effect of bank x on the partial integral worth of the reference bank, equal to the ratio of the integral worth of the reference bank from h^P_x to the fully withdrawn position with and without x in the core.

In addition, included is a list of constants and their definitions as used in this report.

- W^I_x - Measured rod bank worth of bank x from rod exchange

- W^m_{Ref} - Measured rod bank worth of reference bank

- $(\Delta\rho)_x$ (2) - The measured integral worth of the reference bank from the measured critical position (h^m_x) to the fully withdrawn position.

- h^m_x - The measured critical position of the reference bank after interchange with bank x.

- $(h^m_x)_0$ - The initial critical position of the reference bank before exchange with bank x.

- $(\Delta\rho_1)$ - The measured integral worth of the reference bank from 0 steps to $(h^m_x)_0$.

3. <u>Measurement Procedure</u>

With an initial configuration of all rods out, hot zero power, the integral worth of the reference bank is measured using the standard boration/dilution technique. The reference bank is the bank that is predicted to have the highest integral worth. All other banks are then exchanged with the reference bank or other test banks at constant boron conditions until the measured bank is fully inserted.

The worth of each bank is then the amount of reactivity change caused by the withdrawal of the reference bank to its new critical height.

The rod bank worth is inferred from the measured reference bank worth and the measured reference bank height using the following equation:

$$W^{I}_{x} = W^{M}_{ref} - \alpha_x (\Delta\rho_2)_x - (\Delta\rho_1)$$

where the above terms are defined in Section 2.0 of this report.

2. Definitions

The following is a list of the constants needed by the plant, to perform the rod swap procedure. These include:

- W^P_x - Predicted reactivity worth of each control and shutdown bank, when inserted individually into an otherwise unrodded core.

- h^P_x - Predicted critical position of the reference bank after interchange with bank x, starting with the reference bank at 0 steps and bank x fully withdrawn.

- α_x - A correction factor which accounts for the effect of bank x on the partial integral worth of the reference bank, equal to the ratio of the integral worth of the reference bank from h^P_x to the fully withdrawn position with and without x in the core.

In addition, included is a list of constants and their definitions as used in this report.

- W^I_x - Measured rod bank worth of bank x from rod exchange

- W^m_{Ref} - Measured rod bank worth of reference bank

- $(\Delta\rho_2)_x$ - The measured integral worth of the reference bank from the measured critical position (h^m_x) to the fully withdrawn position.

- h^m_x - The measured critical position of the reference bank after interchange with bank x.

- $(h^m_x)_o$ - The initial critical position of the reference bank before exchange with bank x.

- $(\Delta\rho_1)$ - The measured integral worth of the reference bank from 0 steps to $(h^m_x)_o$.

3. Measurement Procedure

With an initial configuration of all rods out, hot zero power, the integral worth of the reference bank is measured using the standard boration/dilution technique. The reference bank is the bank that is predicted to have the highest integral worth. All other banks are then exchanged with the reference bank or other test banks at constant boron conditions until the measured bank is fully inserted.

The worth of each bank is then the amount of reactivity change caused by the withdrawal of the reference bank to its new critical height.

The rod bank worth is inferred from the measured reference bank worth and the measured reference bank height using the following equation:

$$W^{I}_{x} = W^{M}_{ref} - \alpha_x \, (\Delta\rho_2)_x - (\Delta\rho_1)$$

where the above terms are defined in Section 2.0 of this report.

Attachment 4

Responses to Request for Additional Information

Topical Report Numbered DPC-NE-1003, Revision 1, McGuire Nuclear Station and Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testings (TAC NOS. MB3343, MB3344, MB3222, MB3223)

The following pages of this Attachment contain the additional DPC correspondence to be included in Appendix A of the proposed version of this topical report.

DUKE POWER COMPANY
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CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

March 11, 1987

U.S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

Subject: McGuire Nuclear Station
Docket Nos. 50-369/370
Catawba Nuclear Station
Docket Nos. 50-413/414
Determination of Rod Worth Using
Rod Swap Methodology

Gentlemen:

Pursuant to telecons of February 19, 1987 and March 10, 1987 between D.S. Hood (ONRR) et. al., and S.A. Gewehr (DPC) et. al., attached are revised responses to Questions 6 and 7 of D.S. Hood's request for information dated January 12, 1987.

Very truly yours,

H.B. Tucker /

Hal B. Tucker

SAG/61/jgm

Attachment

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PDR ADOCK 05000369
P PDR

A001
1/1

QUESTION 6: Provide data for at least 2 sets of side-by-side comparisons of Boron dilution and Rod Swap Data - predicted and measured. The data may be either for your plants or measured data from another plant and predictions by Duke.

RESPONSE:

In the original Nuclear Physics Methodology Topical, DPC-NF-2010A, Duke Power Company benchmarked its methods for predicting rod worths against measurements made during the startup testing for both initial cores at the McGuire Nuclear Station. These measurements were made using the boration/ dilution technique for determining rod worths in sequential insertion. In its review of this topical, the NRC accepted the capability of Duke Power to adequately predict control rod worths and shutdown margin using the outlined methodology.

In the Rod Swap Methodology Report recently sent to the Commission, Duke Power benchmarked its methodology for predicting rod worths using the rod swap technique against 5 cycles of actual rod swap measurements. This methodology utilized the same computer codes previously benchmarked in DPC-NF-2010A. All predictions, when compared to the measured results, met the acceptance criteria as outlined in the rod swap plant procedure.

It has been noted in previous conversations with the NRC that the two benchmarking studies noted above do not make comparisons of the same units for the same cycles. It is Duke Power's position that there is really no benefit from this type of comparison. A valid comparison cannot be expected since boration/-dilution is a sequential measured worth calculation and rod swap consists of a summation of the worths of each rod individually inserted into an otherwise unrodded core. It is therefore impossible to make direct comparisons between worths of the two methods. The only thing that can be looked at is the percent difference between measured and predicted for th two methods. When looking at percent differences between measured and predicted, one does not have to look at the same unit and cycle to verify methodologies are correct. Comparisons of predicted and measured rod worths done using boration/ dilution and rod swap on the two Catawba units are enclosed. The boration/dilution technique was used to measure rod worths in sequential bank insertion for the Catawba 1 Cycle 1 core while Catawba 2 Cycle 1 measurements were done using the rod swap technique (Table 1). From a neutronics standpoint, the two cores are almost identical. This assumption can be justified by examining the core loadings and the results of the Zero Power Physics Testing for each of the units. Several key parameters concerning the core are shown in Table 2. Also enclosed are the quarter core loading pattern (Figure 1) and a comparison of the quarter core assembly power distribution from the zero power map taken during the startup physics testing (Figure 2).

It should also be pointed out that the rod worths from the rod swap predictions are not the worths used to calculate the shutdown margin. Rod swap only verifies the code's ability to predict rod worths. The rod worth used in the shutdown margin calculation is the N-1 worth.

Duke Power has provided a total of nine cycle of predicted rod worth comparisons to measured data with good to excellent results. This demonstrates the ability of the codes and methods used to adequately model reactivity effects due to control rods in any configuration. Therefore, the use of Duke Power predictions in the verification of shutdown margin with appropriate factors of conservatism applied to the calculation as outlined in DPC-NF-2010A Section 4.2.2.2 is justified.

<u>QUESTION 7:</u> What Organization does the safety analysis for the Duke Plants? When this is not done by Duke, what is done (e.g. tests, comparisons, etc.) to show that the startup test results adequately represent the plant features and assumptions used in the safety analyses?

<u>RESPONSE:</u>

The safety analyses for the McGuire and Catawba Nuclear Stations have been performed by the current fuel vendor. The analyses utilized NRC-approved codes and methodologies and conservative input assumptions including values for key nuclear physics parameters such as reactivity coefficients, core power distributions, and shutdown margins, which are expected to bound the actual values of these parameters for current and future reload cores. An evaluation is performed for each reload cycle which consists of comparing nuclear design predictions to the safety analyses assumptions to ensure the safety analyses remain bounding. The cycle-specific evaluation process is described in WCAP-9272, "Westinghouse Reload Safety Evaluation Methodology." Core physics testing performed for each cycle verifies the nuclear design predictions and ensures the actual core physics parameters are conservative with respect to the safety analyses.

The main safety analysis assumption verified by the rod swap procedure is that the plant will maintain adequate shutdown margin per Technical Specifications. One of the purposes of rod swap measurements and comparisons to predicted values is to verify the accuracy of the total rod worth prediction used as an input to the shutdown margin calculation. An independent Duke Power shutdown margin is evaluated for each cycle using methods approved by the NRC in DPC-NF-2010A. The N-1 rod worth used in this prediction is reduced by 10% for conservatism. Acceptance criteria listed in the procedure indicate that the total inferred rod worth as measured in the rod swap testing must be within 10% of the total predicted worth. If the total measured rod worth is less than the predicted worth by more than 10%, a review of the shutdown margin is made to determine if the current rod insertion limits provide adequate shutdown margin. If the shutdown margin is adequate, then no revision of the limits is necessary. However, if the margin is not maintained, then Duke will notify Westinghouse, revise the rod insertion limits, and submit any necessary changes to Technical Specifications to the NRC.

In order to tie the rod swap measurements to the verification of inputs to the safety analysis, Duke Power will perform an independent shutdown margin for each reload cycle using methods approved by the NRC in DPC-NF-2010A. In addition, for each cycle where Duke generates the rod swap prediction but the safety analysis has been performed by a vendor, a comparison between the Duke and vendor predicted total rod worth will be made at beginning-of-cycle, hot zero power conditions. Any significant discrepancies will be documented, reviewed, and resolved prior to startup physics testing.

<u>Reference</u>

McGuire Nuclear Station, Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testing, DPC-NE-1003, Rev. 1, December 1986.

TABLE 1

Rod Worth Measurement Data
Comparison of Rod Swap and Boration/Dilution Techniques

	Rod Swap Integral Worths			Boron/Dilution Integral Worths		
Bank	Predicted (PCM)	Measured (PCM)	% Diff**	Predicted (PCM)	Measured (PCM)	% Diff**
D	772	794	-2.85	773	788	-1.94
C	790	849	-7.47	1214	1203	0.91
B*	852	882	-3.52	1190	1171	1.60
A	249	250	-0.40	572	548	4.20
SE	377	385	-2.12	508	460	9.45
SD	497	525	-5.63	755	772	-2.25
SC	497	522	-5.03	1098	1099	-0.09
SB	765	834	-9.02	-	-	-
SA	674	706	-4.75	-	-	-
N-1	-	-	-	7370	7414	-.60
N	5473	5747	-5.01			

* Reference Bank

** % Diff = [(P-M)/P]*100

TABLE 2

Catawba 1 Cycle 1 and Catawba 2 Cycle 1
Comparison of Core Parameters

	Unit 1	Unit 2
KG U/ASSY		
Batch 1 1.6	424.169	424.623
Batch 2 2.4	423.508	425.805
Batch 3 3.1	423.676	424.519
AVE ENR		
Batch 1	1.6101	1.6104
Batch 2	2.3999	2.4014
Batch 3	3.1022	3.0954
ARO BORON ENDPOINT (PPMB)	975	975
ISO. TEMP. COEFF (PCM/°F)	-1.745	-1.81

Figure 1

CATAWBA 1 CYCLE 1 AND CATAWBA 2 CYCLE 1
QUARTER CORE LOADING PATTERN

	H	G	F	E	D	C	B	A
8	1.60	2.40 16	1.60	2.40 12	1.60	2.40 16	1.60	3.10 6
9	2.40 16	1.60	2.40 12	1.60	2.40 12	1.60	3.10 20	3.10
10	1.60	2.40 12	1.60	2.40 12	1.60	2.40 16	1.60	3.10 6
11	2.40 12	1.60	2.40 12	1.60	2.40 16	1.60	3.10 16	3.10
12	1.60	2.40 12	1.60	2.40 16	2.40	2.40 16	3.10	
13	2.40 16	1.60	2.40 16	1.60	2.40 16	3.10 15	3.10	
14	1.60	3.10 20	1.60	3.10 16	3.10	3.10	ENRICHMENT NUMBER OF BA'S PER ASSY	
15	3.10 6	3.10	3.10 6	3.10				

Figure 2

C1C1 AND C2C1 HZP POWER DISTRIBUTIONS 0 MWD/MTU

ARO, HZP, NO XE, NO SM

	H	G	F	E	D	C	B	A
8	.72	.82	.84	1.00	.89	.97	.95	.97
	.72	.82	.82	.97	.87	.94	.93	.95
	0.00	0.00	2.44	3.09	2.30	3.19	2.15	2.11
9	.82	.79	.95	.80	1.02	.91	1.11	1.01
	.82	.78	.95	.80	1.01	.89	1.10	1.00
	0.00	1.28	0.00	0.00	.99	2.25	.91	1.00
10	.83	.96	.89	1.04	.93	1.01	.93	.90
	.83	.95	.89	1.05	.93	1.01	.93	.89
	0.00	1.05	0.00	-.95	0.00	0.00	0.00	1.12
11	1.01	.90	1.06	.99	1.12	1.03	1.16	.73
	1.00	.89	1.06	.99	1.12	1.03	1.17	.74
	1.00	1.12	0.00	0.00	0.00	0.00	-.85	-1.35
12	.91	1.04	.94	1.12	1.43	1.19	1.22	
	.91	1.04	.93	1.13	1.44	1.19	1.23	
	0.00	0.00	1.08	-.88	-.69	0.00	-.81	
13	.98	.92	1.03	1.04	1.19	1.22	.89	
	1.01	.94	1.04	1.06	1.20	1.21	.88	
	-2.97	-2.13	-.96	-1.89	-.83	.83	1.14	
14	.97	1.14	.96	1.18	1.22	.88		
	.98	1.16	.97	1.19	1.22	.89		
	-1.02	-1.72	-1.03	-.84	0.00	-1.12		
15	1.00	1.04	.92	.74	C1C1			
	1.00	1.04	.93	.76	C2C1			
	0.00	0.00	-1.08	-2.63	% DIFF			

C1C1 CORE AVERAGE 1.00
C2C1 CORE AVERAGE 1.00
% DIFF CORE AVERAGE -.05

C1C1 MAXIMUM MAGNITUDE IS 1.43 AT ASSEMBLY D - 12
C2C1 MAXIMUM MAGNITUDE IS 1.44 AT ASSEMBLY D - 12
% DIFF MAXIMUM MAGNITUDE IS 3.19 AT ASSEMBLY C - 8
PERCENT ERROR BETWEEN THE MAXIMUM VALUES IS -.69

AVERAGE ABSOLUTE RELATIVE ERROR .88 PERCENT
ROOT MEAN SQUARE OF THE RELATIVE ERROR 1.22 PERCENT
ROOT MEAN SQUARE OF THE DIFFERENCE 1.16 PERCENT

Attachment 4
Responses to Request for Additional Information
Topical Report Numbered DPC-NE-1003, Revision 1, McGuire Nuclear Station and Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testings
(TAC NOS. MB3343, MB3344, MB3222, MB3223)

The following pages of this Attachment contain an information only copy of the current rod swap procedure. This is being provided in response to Question 4.c.

Form 34731 (R8-94)

Duke Power Company
PROCEDURE PROCESS RECORD

ID No. PT/0/A/4150/11A

Change(s) 0 to 24 incorporated

PREPARATION

(2) Station McGuire Nuclear Station

(3) Procedure Title Control Rod Worth Measurement [illegible]

FOR INFORMATION ONLY

(4) Prepared By Tanya M. Hamilton-Dooley Date 01/19/96

(5) Requires 10CFR50.59 evaluation?

- [x] Yes (New procedure or reissue with major changes)
- [ ] No (Reissue with minor changes OR to incorporate previously approved changes)

(6) Reviewed By Jerry B. Daye Date 1-19-96

Cross-Disciplinary Review By ______ N/R JBD Date ______

(7) Additional Reviews

Reviewed By SC Ballard Date 1-19-96

Reviewed By ______ Date ______

(8) Temporary Approval *(if necessary)*

By ______ (SRO) Date ______

By ______ Date ______

(9) Approved By [signature] Date 1/19/96

PERFORMANCE (compare with control copy every 14 calendar days)

(10) Compared with Control Copy ______ Date ______

Compared with Control Copy ______ Date ______

Compared with Control Copy ______ Date ______

(11) Date(s) Performed ______

Work Order Number (WO#) ______

FOR INFORMATION ONLY

COMPLETION

(12) Procedure Completion Verification

- [ ] Yes [ ] N/A Check lists and/or blanks properly initialed, signed, dated or filled in N/A or N/R, as appropriate?
- [ ] Yes [ ] N/A Listed enclosures attached?
- [ ] Yes [ ] N/A Data sheets attached, completed, dated and signed?
- [ ] Yes [ ] N/A Charts, graphs, etc. attached and properly dated, identified and marked?
- [ ] Yes [ ] N/A Procedure requirements met?

Verified By ______ Date ______

(13) Procedure Completion Approved ______ Date ______

(14) Remarks *(attach additional pages, if necessary)*

ATTACHMENT TO THE PROCEDURE PROCESS RECORD:

Procedure Title: Control Rod Worth Measurement: Rod Swap

Changes included in the reissue:

Section 2.0	The following references were added: - FSAR Section 14.3.2.3 - Technical Specification 3.10.3 - SER for Duke Power Rod Swap Methodology Report for Startup Physics Testing, May 22, 1987 The following Support Documents were added: - PT/0/A/4150/10, Boron Endpoint Measurement
Section 3.0	Time requirements changed from six to eight hours
Section 4.0	PT/0/A/4150/10, Boron Endpoint Measurement was removed as a prerequisite test.
Section 5.0	Step 5.1 was revised to better define the required reactivity computer. Step 5.2 was added to define the scale of the 2 pen strip chart recorder for the reactivity computer setup. Step 5.3 was added to recommend (optional) monitoring of Tave during testing.
Section 6.0	The following Limits and Precautions were added: -If a stable startup rate of 0.5 DPM is achieved, insert rods to reduce startup rate to less than 0.5 DPM. If the startup rate is greater than or equal to 1.0 DPM, immediately trip the reactor. - Avoid makeup to the VCT during rod swap evolution. - Keep reactivity between - 50 pcm and 75 pcm during rod swap. -Adjustments to procedure are required if any bank (other than Bank 8) is worth more than the reference bank.
Section 8.0	- Step 8.2 was deleted. - Step 8.3 was changed to specify a pcm limit. - Step 8.6 was revised to match the Startup Physics Test Program notation of 2235 $\pm$ 50 psig in addition to providing the corresponding pressure range. - Step 8.5 was revised to match the Startup Physics Test Program notation of 557 $\pm$ 2 °F in addition to providing the corresponding temperature range. The following Prerequisite System Conditions were added to ensure stable test conditions, to ensure NC system boron remains stable and to aid in setup of the reactivity computer: - Test equipment setup per Section 5.0 - Rod Control System has been checked per Enclosure 13.10
Section 11.0	- Changes all references of Design Engineering to G.O. Nuclear Engineering
Section 12.0	- Revised procedure to reflect change #24 throughout (20 to 40 pcm limit).

Section 12.0 (cont.)

- Added - NOTES:
1. The following steps ensure that no VCT makeup is required during rod swap.
2. To reduce pump head loss, all additions should occur directly to the suction of the NV pumps (through NV-175 or NV-265), NOT to the top of the VCT (through NV-171). Auto Makeup Limit = 41.4% and Low Level Alarm = 15.7%.

- Added - CAUTION - Ensure that VCT pressure does not exceed 30 psig while performing Step 12.2. This may require batching the additions to allow the VCT pressure controller adequate time to operate. Failure to do so may result in misoperation of the boric acid transfer pump
- Added Step 12.2 - Ensure that the VCT level is sufficient such that makeup will not be required for approximately 4 hours.
- Added Step 12.4 - Verify that drift in the reactivity trace over that last 30 minutes is less than 5 pcm.
- Added NOTE - Temporary signs will be provided for the OATC to assist in designating rod group being withdrawn and rod group being inserted.
- Added Step 12.16 - Any temporary signs provided for the OATC to assist in designating rod group being withdrawn and rod group being inserted should be removed from the Control Room upon completion of this test.

The procedure was updated to follow the current procedure writers guidelines for NOTES, CAUTIONS, IFs, etc. Additionally, the procedure steps were renumbered as needed.

DUKE POWER COMPANY
McGUIRE NUCLEAR STATION
CONTROL ROD WORTH MEASUREMENT: ROD SWAP

1.0 PURPOSE

NOTE: The reference bank is the bank which has the predicted highest reactivity worth of all control and shutdown banks when inserted into an otherwise unrodded core.

1.1 To determine the worth of all control and shutdown banks, except the reference bank, as inferred from an iso-reactivity interchange with the reference bank.

1.2 To verify that the reactivity worth of each control and shutdown bank (except the reference bank), as inferred from data following iso-reactivity interchange with the reference bank, is consistent with design predictions.

2.0 REFERENCES

2.1 Source Documents:

2.1.1 Rod Bank Worth Measurements Utilizing Bank Exchange, WCAP-9863-A, May 1982.

2.1.2 Duke Power Company, McGuire Nuclear Station, Catawba Nuclear Station, Startup Physics Test Program, April 8 1988.

2.1.3 Operating Experience Program Commitment 1-91-41-001A.

2.1.4 Significant Event Report 90-15.

2.1.5 FSAR Section 14.3.2.3

2.1.6 Technical Specification 3.10.3

2.1.7 NSD 213, "Conduct of Infrequently Performed Tests or Evolutions".

2.1.8 SER for Duke Power Rod Swap Methodology Report for Startup Physics Testing, May 22, 1987.

2.2 Support Documents:

2.2.1 Control Rod Worth Measurement, PT/0/A/4150/11

2.2.2 Post Refueling Controlling Procedure for Criticality, Zero Power Physics Test, and Power Escalation Testing, PT/0/A/4150/21

2.2.3 MNS Technical Specifications

- Surveillance Requirement 3.1.1.1
- Surveillance Requirement 3.10.4
- Surveillance Requirement 3.10.3
- Surveillance Requirement 3.10.2.

2.2.4 Duke Power Company, Startup and Operational Report for appropriate unit and cycle.

2.2.5 RODSWAP computer application User's Guide

2.2.6 PT/0/A/4150/10, Boron Endpoint Measurement

3.0 TIME REQUIRED

3.1 Duration: 8 hours

3.2 Personnel Required: Two Engineers

4.0 PREREQUISITE TESTS

None

5.0 TEST EQUIPMENT

5.1 Westinghouse Digital Reactivity Computer or equivalent, (with flux signal from top and bottom of one power range channel).

5.2 One 2 pen strip chart recorder with reactivity (±100 pcm scale) and flux signal inputs.

5.3 One strip chart recorder monitoring NC Tave (optional).

6.0 LIMITS AND PRECAUTIONS

6.1 If a stable startup rate of 0.5 DPM is achieved, insert rods to reduce startup rate to less than 0.5 DPM. If the startup rate is greater than or equal to 1.0 DPM, immediately trip the reactor.

6.2 The NC system temperature is 557°F ± 2°F (555°F to 559°F), and controlled preferably by steam dump to the condenser. Temperature may be controlled by other methods as required by system conditions.

6.3 Normally all reactor coolant pumps should be operating for maximum mixing in the NCS. If all reactor coolant pumps are not operating, the operating pumps should be those on the NCS charging loops (A and/or D). See Tech Spec 3.4.1.1 and 3.10.4 if all reactor coolant pumps are not operating.

6.4 The rod insertion limit and bank overlap sequence will be violated during this test. The Unit SRO and OATC should be made aware in advance and should anticipate the associated alarms. Technical Specification 3.10.3 allows for this violation.

6.5 Maintain the flux level in the zero power test range established in PT/0/A/4150/21.

6.6 If bank has two groups, both must be at the same position prior to switching rod control selector switch between banks to avoid group misalignment.

6.7 If any unexpected, inadvertent drop of an RCCA(s) or Bank(s) of RCCAs occurs, recommend to Unit SRO immediate initiation of manual reactor shutdown. (OEP Commitment 1-91-41-001A)

6.8 Avoid makeup to VCT during rod swap evolution.

6.9 Keep reactivity between - 50 pcm and 75 pcm during rod swap.

6.10 Adjustments to procedure are required if any bank (other than Bank 8) is worth more than the reference bank.

7.0 REQUIRED UNIT STATUS

Initial

____ Mode 2 with the flux level in the zero power physics test band established in PT/0/A/4150/21.

8.0 PREREQUISITE SYSTEM CONDITIONS

NOTES:		
	1)	The following steps may be signed off in any order.
	2)	See Enclosure 13.1 for an explanation of nomenclature used in this test.
	3)	Banks should be measured in order of increasing predicted worth.
	4)	Step 8.6 may be performed prior to any other Section 8 step.

Initial		
___	8.1	Complete Enclosure 13.2.
___	8.2	Ensure the reactor is critical with all control and shutdown banks fully withdrawn except the Reference Bank which is < 50 pcm from fully inserted.
___	8.3	The Rod Control Selector switch is in Bank Select Mode set the Reference Bank.
___	8.4	Reactor coolant system temperature is 557 ± 2°F (555 °F to 559°F).
___	8.5	Reactor coolant system pressure is 2235 ± 50 psig (2185 to 2285).
___	8.6	Complete Enclosure 13.9.
___	8.7	IF available, start computer application, RODSWAP, as directed by reference 2.2.5.
___	8.8	Test equipment is setup per section 5.0
___	8.9	Rod Control System has been checked per Enclosure 13.10

Sections 7.0 and 8.0 Performed By/Date: ______________________________

9.0 TEST METHOD

The bank with the highest predicted value of reactivity worth has been measured using the dilution technique per PT/0/A/4150/11. This bank serves as a reference. The integral worth of the remaining banks is implied from the difference in the critical rod position of the reference bank with and without the insertion of bank being tested. The implied integral worths are then compared to predicted rod worths.

10.0 DATA REQUIRED

10.1 The following conditions for the approximate time of criticality after each bank exchange, recorded on Enclosure 13.3:

- Time
- Critical height of reference bank

10.2 Nuclear design predictions on Enclosure 13.2.

10.3 A copy of the rod positions and rod worths for the reference bank from Enclosure 13.2 of PT/0/A/4150/11.

10.4 The calculated, implied integral worth W_x^I for each RCC bank except the reference bank. List data on Enclosure 13.3 OR from RODSWAP printout attached to Enclosure 13.6.

10.5 The percent difference between inferred and predicted worths for each individual RCC banks ε_1 and for the sum of all banks ε_2 on Enclosure 13.7 OR on RODSWAP printout attached to Enclosure 13.6.

11.0 ACCEPTANCE CRITERIA

NOTES:

1) The appropriate actions for failure of an acceptance or review criteria are as follows:

Acceptance Criteria: G.O. Nuclear Engineering shall:

- Provide concurrence to continue testing.
- Investigate and provide solution within 30 days of the test.
- Submit a report of the findings to the NRC within 45 days of the test.

Review Criteria: G.O. Nuclear Engineering shall:

- Investigate and provide solution within 60 days of the test.
- Submit a report of the findings to the NRC within 75 days of the test.

2) For calculating percent differences, use $\left(\frac{\text{Meas}}{\text{Pred}} - 1\right) \times 100\%$

11.1 Acceptance Criteria

11.1.1 The sum of all banks (ε_2) >90% of predicted.

11.1.2 For all banks other than the reference bank, from Enclosure 13.7 either:

a) $(\varepsilon_1)_x$ is $\pm$30% of predicted for each bank x

OR

b) $(W_x^P - W_x^I)$ is $\pm$ 200 pcm of predicted for each bank x, whichever is greater.

11.1.3 All banks, both control and shutdown banks, are measured.

11.2 Review Criteria:

11.2.1 From Enclosure 13.7, the sum of all banks (ε_2) is $\leq$110%.

11.2.2 For all banks other than the reference bank, from Enclosure 13.7, either:

a) $(\varepsilon_1)_x$ is ±15% of predicted for each bank x

<u>OR</u>

b) $(W_x^P - W_x^I)$ is ± 100 pcm of predicted for each bank x, whichever is greater.

12.0 PROCEDURE

Initial

NOTE:	All banks except reference bank are referred to by bank number identified on Enclosure 13.2.

____ 12.1 Attach Enclosure 13.2 of PT/0/A/4150/11 and label as Enclosure 13.8.

NOTES:	1) Step 12.2 ensures that no VCT makeup is required during rod swap. 2) To reduce pump head loss, all additions should occur directly to the suction of the NV pumps (through NV-175 or NV-265), NOT to the top of the VCT (through NV-171). Auto Makeup Limit = 41.4% and Low Level Alarm = 15.7%.

CAUTION:	Ensure that VCT pressure does not exceed 30 psig while performing Step 12.2. This may require batching the additions to allow the VCT pressure controller adequate time to operate. Failure to do so may result in misoperation of the boric acid transfer pump.

____ 12.2 Ensure that the VCT level is sufficient such that makeup will not be required for approximately 4 hours.

____ 12.3 Verify that drift in the reactivity trace over that last 30 minutes is less than 5 pcm.

NOTE:	The first assigned bank on Enclosure 13.2 is referred to as Bank 1.

12.4 Measure integral worth of first assigned bank of Enclosure 13.2 as follows:

____ 12.4.1 Record initial critical position of reference bank $(h_x^M)_o$ on Enclosure 13.3.

CAUTION:	1) When switching from one bank to another, step counters for both groups, for banks with two groups, must be indicating the same step number to avoid rod misstepping. 2) During rod exchange, ensure limits and precautions per Step 6.8 are observed.

NOTE:	Temporary signs will be provided for the OATC to assist in designating rod group being withdrawn and rod group being inserted.

____ 12.4.2 Direct Operations to insert bank 1 until indicated reactivity is approximately - 40 pcm.

____ 12.4.3 Direct Operations to withdraw reference bank until indicated reactivity is approximately + 40 pcm.

____ 12.4.4 Repeat Steps 12.4.2 and 12.4.3 until bank 1 is fully inserted maintaining indicated reactivity at approximately ± 40 pcm.

____ 12.4.5 Direct Operations to adjust position of reference bank until reactor is critical.

___ 12.4.6 Record final critical configuration data (h_x^M) on Enclosure 13.3.

12.5 Measure integral worth of remaining assigned banks as follows:

NOTES:	1)	The bank being measured is denoted as bank N.
	2)	The previously measured bank is denoted as bank N-1.
	3)	N = 2 for the second assigned bank.

___ 12.5.1 Direct Operations to insert bank N until indicated reactivity is approximately - 40 pcm.

___ 12.5.2 Direct Operations to withdraw bank N-1 until indicated reactivity is approximately + 40 pcm.

___ 12.5.3 Repeat Steps 12.5.1 and 12.5.2 until bank N is fully inserted or bank N-1 is fully withdrawn.

___ 12.5.4 IF bank N is fully inserted before bank N-1 is fully withdrawn, direct Operations to insert reference bank, compensating with withdrawal of bank N-1, maintaining indicated reactivity approximately ± 40 pcm throughout, until critical conditions are achieved with bank N-1 fully withdrawn.

___ 12.5.5 IF bank N-1 is fully withdrawn before bank N is fully inserted, direct Operations to withdraw reference bank, compensating with insertion of bank N, maintaining indicated reactivity approximately ± 40 pcm throughout, until critical conditions are achieved with bank N fully inserted or reference bank is fully withdrawn.

___ 12.5.6 IF bank N is not fully inserted and reference bank is fully withdrawn, mark Steps 12.5.7 and 12.5.8 N/A AND measure bank after others.

___ 12.5.7 Adjust position of reference bank until reactor is critical.

___ 12.5.8 Record final critical configuration data (h_x^M) on Enclosure 13.3.

___ 12.5.9 Repeat Steps 12.5.1 through 12.5.8 using Enclosure 13.4 for step signoffs to measure integral worths of assigned bank N = 3 through 7.

12.6 Measure integral worth of bank 8 as follows:

___ 12.6.1 Direct Operations to insert bank 8 until indicated reactivity is approximately - 40 pcm.

___ 12.6.2 Direct Operations to withdraw bank 7 until indicated reactivity is approximately + 40 pcm.

___ 12.6.3 Repeat Steps 12.6.1 and 12.6.2 until bank 8 is fully inserted OR bank 7 is fully withdrawn.

___ 12.6.4 IF bank 8 is fully inserted before bank 7 is fully withdrawn, insert reference bank, compensating with withdrawal of bank 7, maintaining indicated reactivity between ± 40 pcm throughout until critical conditions.

___ 12.6.5 IF bank 7 is fully withdrawn before bank 8 is fully inserted, withdraw reference bank compensating with insertion of bank 8 maintaining indicated reactivity between ± 40 pcm throughout, until critical conditions are achieved with bank 8 fully inserted OR reference bank is fully withdrawn.

___ 12.6.6 IF bank 8 is fully inserted with reference bank not fully withdrawn, direct Operations to adjust reference bank position to critical and record h_x^M on Enclosure 13.3.

12.6.7 IF bank 8 is NOT fully inserted and reference bank is fully withdrawn, perform the following:

___ 12.6.7.1 IF remaining worth of bank 8 to be inserted is estimated to be less than approximately 50 pcm, measure remaining worth by inserting bank 8 to 0 steps and measure worth using reactivity computer. Record worth on Enclosure 13.3 in column for $\alpha_x(\Delta\rho_2)_x$.

12.6.7.2 IF remaining worth of bank 8 to be inserted is estimated to be greater than approximately 50 pcm, perform the following:

___ a) Swap bank 8 for reference bank until bank 8 is fully withdrawn.

b) Record reference bank inserted, final critical point (h_x^M) final on Enclosure 13.5 and Enclosure 13.3 for bank 7.

___ c) On Enclosure 13.5, mark bank 8 drift as N/A and divide drift by 7 to get drift/bank.

___ d) Swap bank 8 for reference bank until reference bank is fully withdrawn.

NOTE:	It is permissible to insert another bank to maintain the reactor critical.

___ e) Direct Operations to commence a slow NC system dilution and measure remaining worth of bank 8 using reactivity computer.

___ 12.7 Direct Operations to insert reference bank until indicated reactivity is approximately - 40 pcm.

___ 12.8 Direct Operations to withdraw bank 8 until indicated reactivity is approximately + 40 pcm.

___ 12.9 Repeat Steps 12.7 and 12.8 maintaining indicated reactivity approximately ± 40 pcm, until bank 8 is fully withdrawn and critical conditions are achieved.

12.10 IF Step 12.6.7.2 was NOT performed, perform the following:

- Record $(h_x^M)_o$ on Enclosures 13.3 and 13.5.
- Divide through by 8 on Step 13.5.6 of Enclosure 13.5. ___

___ 12.11 Complete Enclosure 13.5.

NOTE:	**If** computer application, RODSWAP is used, Step 12.12 and any unused blanks on Enclosures 13.3, 13.5, and 13.6 may be marked N/A.

12.12 Compute inferred worth for each control and shutdown bank (except reference bank) as follows:

12.12.1 Using data from Enclosure 13.3, and worth measurement data for reference bank from Enclosure 13.8, record value of $(\Delta\rho_1)_x$ on Enclosure 13.3.

___ 12.12.2 IF bank being measured has a worth greater than reference bank worth, replace $\alpha_x(\Delta\rho_2)_x$ with worth measured by reactivity computer:

$$\left[W_x^M\right]_{h_x^M}^{FW}$$

___ 12.12.3 Using data from Enclosure 13.3, worth measurement data for reference bank from Enclosure 13.8 and data of Enclosure 13.2, compute value of $\alpha_x(\Delta\rho_2)_x$ as described below and record on Enclosure 13.3:

$$\alpha_x(\Delta\rho_2)_x = \alpha_x\left[W_R^M\right]_{h_x^M}^{FW}$$

where: $\left[W_R^M\right]_{h_x^M}^{FW}$ is the measured integral worth of the reference bank from h_x^M to the fully withdrawn position from Enclosure 13.8. Linearly interpolate if h_x^M does not correspond to the steps on Enclosure 13.8.

h_x^M is the measured critical position of the reference bank after interchange with bank x from Enclosure 13.3.

and

α_x is a correction factor from Enclosure 13.2 to account for the influence of bank x on the worth of the reference bank.

___ 12.12.4 IF bank being measured has a worth greater than the reference bank worth, compute the inferred integral worth of the bank and record on Enclosure 13.3:

$$W_x^I = W_R^M + \left[W_x^M\right]_{h_x^M}^{FW} - (\Delta\rho_1)_x$$

where $\left[W_x^M\right]_{h_x^M}^{FW}$ is given in the column marked $\alpha_x(\Delta\rho_2)_x$ on Enclosure 13.3.

___ 12.12.5 Compute inferred integral worth of each bank x, W_x^I, as described below and record on Enclosure 13.3:

$$W_x^I = W_R^M - (\Delta\rho_1)_x - \alpha_x(\Delta\rho_2)_x$$

where: W_R^M is the measured total integral reference bank worth from Enclosure 13.8.

$(\Delta\rho_1)_x$ is from step 12.12.1.

and

$\alpha_x(\Delta\rho_2)_x$ is from step 12.12.2 or 12.12.3.

___ 12.12.6 Compute difference and percent difference between inferred and predicted worths for each individual RCC bank and the sum of all banks described below.

$$(\varepsilon_1)_x = \left(\frac{W_x^I}{W_x^P} - 1\right) \times 100\%$$

$$\varepsilon_2 = \left(\frac{\sum_{i=1}^{N} W_i^I}{\sum_{i=1}^{N} W_i^P}\right) \times 100\%$$

Fill in all blanks and summarize the calculations on Enclosure 13.6.

___ 12.13 IF computer application, RODSWAP, is used, attach printout to Enclosure 13.6.

___ 12.14 Complete Enclosure 13.7.

12.15 Verify all acceptance and review criteria have been met, or appropriate actions are being taken.

12.16 Any temporary signs provided for the OATC to assist in designating rod group being withdrawn and rod group being inserted should be removed from the Control Room upon completion of this test.

13.0 ENCLOSURES

13.1 Nomenclature
13.2 Nuclear Design Predictions for Rod Exchange Measurements
13.3 Critical Configuration and Worth Calculation Sheet
13.4 Additional Signoffs for Banks 3 through 7
13.5 Reference Bank Drift Evaluation
13.6 Comparison of Inferred Bank Worths with Design Predictions
13.7 Review Criteria Evaluation
13.8 Reference Bank Integral Worth
13.9 Requirements for Infrequently Performed Tests
13.10 Rod Control Cabinet Group Select Light Checkout

ENCLOSURE 13.1
NOMENCLATURE

1. W_x^P — Predicted reactivity worth of each control and shutdown bank when inserted individually into an otherwise unrodded core.

2. W_x^I — The calculated, implied rod bank worths of bank x from rod exchange.

3. W_R^M — Measured rod bank worth of reference bank.

4. α_x — A correction factor which accounts for the effect of bank x on the partial integral worth of the reference bank, equal to the ratio of the integral worth of the reference bank from h_x^P to the fully withdrawn position with and without x in the core.

5. $(\Delta\rho_2)_x$ — The measured integral worth of the reference bank from h_x^M to the fully withdrawn position.

6. h_x^P — The predicted critical position of the reference bank after interchange with bank x starting with reference bank at 0, bank x fully withdrawn.

7. h_x^M — The measured critical position of the reference bank after interchange with bank x.

8. $\left[W_R^M\right]_0^{(h_x^M)_o}$ — The measured integral worth of the reference bank from 0 steps to $(h_x^M)_o$; equivalent to $(\Delta\rho_1)_x$.

9. $(h_x^M)_o$ — Initial critical position of the reference bank before interchange with bank x.

10. $\left[W_R^M\right]_{h_x^M}^{FW}$ — The measured integral worth of the reference bank from h_x^M to the fully withdrawn position.

ENCLOSURE 13.2
NUCLEAR DESIGN PREDICTIONS FOR ROD EXCHANGE MEASUREMENTS

McGuire Unit _____ Cycle _____

Bank No. (x)	Bank Identity +	W_x^P (pcm)	(b) h_x^P (steps)	(c) α_x
(a) Reference			N/A	N/A
1				
2				
3				
4				
5				
6				
7				
8				

(a) Reference bank - the bank with the highest predicted integral worth.

(b) Reference bank critical position after interchange with bank x.

(c) Ratio of integral worth of the reference bank from h_x^P to the fully withdrawn position with and without bank x in the core.

\+ Control Bank C, Shutdown Bank E, etc.

NOTE: See Enclosure 13.1 for a complete listing of nomenclature used in this test.

Recorded By ____________________ Date ____________________

This data came from (list source and document number): ____________________

____

McGuire Unit _____ Cycle _____

ENCLOSURE 13.3
CRITICAL CONFIGURATION AND WORTH CALCULATION SHEET

Bank (x)	Date/Time	$(h_x^M)_o$	(h_x^M)	* $(\Delta\rho_1)_x$	* $\alpha_x(\Delta\rho_2)_x$	* W_x^I
No. Ident.	N/A	(steps)	(steps)	(pcm)	(pcm)	(pcm)
1						
2		N/A				
3		N/A				
4		N/A				
5		N/A				
6		N/A				
7						
8						

* NOTE: IF bank being measured has a worth greater than the reference bank worth, these values will be as given by Enclosure 13.5 or Step 12.4.7.2.

Recorded By____________________Date___________

CHG # 25
TDR 1/24/96

ENCLOSURE 13.4
ADDITIONAL SIGNOFFS FOR BANKS 3 THROUGH 7

Bank	3	4	5	6	7
Step					
12.5.1	___	___	___	___	___
12.5.2	___	___	___	___	___
12.5.3	___	___	___	___	___
12.5.4	___	___	___	___	___
12.5.5	___	___	___	___	___
12.5.6	___	___	___	___	___
12.5.7	___	___	___	___	___
12.5.8	___	___	___	___	___

Section 12.5 Performed By/Date: ______________________________

ENCLOSURE 13.5
REFERENCE BANK DRIFT EVALUATION

McGuire Unit _____ Cycle _____

Step

13.5.1 Final Reference Bank Critical Position __________ steps

13.5.2 Initial Reference Bank Critical Position __________ steps

13.5.3 Reactivity worth of reference bank from 0 to position of Step 13.5.1 __________ pcm

13.5.4 Reactivity worth of reference bank from 0 to position of Step 13.5.2. __________ pcm

13.5.5 Difference of Step 13.5.3 and 13.5.4 (Circle correct sign)

13.5.3 - 13.5.4 = ________ - ________ = ±__________ pcm

NOTE: Round Step 13.5.6 to the nearest pcm.

13.5.6 Incremental drift for each bank
(Circle correct sign and circle either 8 or 7 as appropriate)
(See Step 12.4.7.2.c)

Step 13.5.5 / 8 or 7 = __________ / 8 or 7 ±__________ pcm

13.5.7 $(\rho_1)_x$ for banks:

bank 1	Step 13.5.4		__________ pcm
bank 2	Step 13.5.4 + 13.5.6	_______ + _______	__________ pcm
bank 3	bank 2 + 13.5.6	_______ + _______	__________ pcm
bank 4	bank 3 + 13.5.6	_______ + _______	__________ pcm
bank 5	bank 4 + 13.5.6	_______ + _______	__________ pcm
bank 6	bank 5 + 13.5.6	_______ + _______	__________ pcm
bank 7	bank 6 + 13.5.6	_______ + _______	__________ pcm
bank 8	bank 7 + 13.5.6	_______ + _______	__________ pcm

Recorded By ____________________ Date __________
Checked By ____________________ Date __________

ENCLOSURE 13.6
COMPARISON OF INFERRED BANK WORTHS WITH DESIGN PREDICTIONS

McGuire Unit _____ Cycle _____

NOTE: Round rod worth numbers to the nearest pcm.

Bank (x) No.	Bank (x) Ident.	* W_x^P (pcm)	++ W_x^I (pcm)	$(W_x^P - W_x^I)$ (pcm)	$(\varepsilon_1)_x$ (%)
Reference			+		
1					
2					
3					
4					
5					
6					
7					
8					
		$\sum W_x^P$ (pcm)	$\sum W_x^I$ (pcm)		ε_2 (%)

+Record the measured worth of the reference bank here.

*from Enclosure 13.2

++from Enclosure 13.3

Recorded By ______________________ Date______

Checked By ______________________ Date______

ENCLOSURE 13.7
REVIEW CRITERIA EVALUATION

McGuire Unit _____ Cycle _____

NOTE: <u>IF</u> any of the below Review Criteria are checked "No", notify G.O. Nuclear Design by the next working day.

		Yes (√)	No (√)
I.	Review Criteria 11.2.1: sum of all banks (ε_2) from Enclosure 13.6 is $\leq$110%.	___	___
II.	Review Criteria 11.2.2: for each bank x $(\varepsilon_1)_x$ from Enclosure 13.6 is $\pm$15% or $(W_x^P - W_x^I)$ from Enclosure 13.6 is $\pm$100 pcm, whichever is greater.	___	___

Bank x No.	Ident.	Yes (√)	No (√)
1	_____	___	___
2	_____	___	___
3	_____	___	___
4	_____	___	___
5	_____	___	___
6	_____	___	___
7	_____	___	___
8	_____	___	___

Recorded by ______________________________ Date ______________

Checked by ______________________________ Date ______________

ENCLOSURE 13.9
REQUIREMENTS FOR INFREQUENTLY
PERFORMED TESTS

This test, which involves exchanging (swapping) a bank with either the Reference Bank and/or the previous bank to measure its reactivity worth, involves additional requirements and management involvement since it is an infrequently performed test. The guidance in this enclosure establishes an environment that places a high priority on preserving the plant's nuclear safety which is management's prime responsibility.

The Management Designee's responsibility is to ensure management expectations are met and that the evolution is controlled appropriately. The Management Designee can stop the evolution at any point that is deemed necessary or appropriate and provide the Operations Shift Supervisors with guidance for any recovery actions.

The Evolution Coordinator's responsibility is overall coordination of the evolution to ensure it is done in a safe controlled manner. The Evolution Coordinator can stop the evolution at any point that is deemed necessary or appropriate and provide the Operations Shift Supervisor with guidance for any recovery actions. (Reference SOER 91-01)

The Management Designee shall initial and date the steps below when completed.

____ 1.0 Record the following:

Evolution Coordinator ______________________________

Management Designee ______________________________

____ 2.0 A pre-job briefing has been performed by the Management Designee.

ENCLOSURE 13.10
ROD CONTROL CABINET
GROUP SELECT LIGHT CHECKOUT

NOTE: Shutdown and control banks may be done in any order.

(✓)

_____ 1.0 SHUTDOWN BANK A (SDA)

1.1 Have OATC select SDA on "CRD BANK SELECT"

1.2 Verify that only "GRP SELECT" light "C" is illuminated on Rod Control Power Cabinets 1AC and 2AC.

_____ 2.0 SHUTDOWN BANK B (SDB)

2.1 Have OATC to select SDB on "CRD BANK SELECT"

2.2 Verify that only "GRP SELECT" light "C" is illuminated on Rod Control Power Cabinets 1BD and 2BD.

_____ 3.0 SHUTDOWN BANK C (SDC)

3.1 Have OATC to select SDC on "CRD BANK SELECT"

3.2 Verify that only "GRP SELECT" light "A" is illuminated on Rod Control Power Cabinet SCDE .

_____ 4.0 SHUTDOWN BANK D (SDD)

4.1 Have OATC to select SDD on "CRD BANK SELECT"

4.2 Verify that only "GRP SELECT" light "B" is illuminated on Rod Control Power Cabinet SCDE.

_____ 5.0 SHUTDOWN BANK E (SDE)

5.1 Have OATC to select SDE on "CRD BANK SELECT"

5.2 Verify that only "GRP SELECT" light "C" is illuminated on Rod Control Power Cabinet SCDE.

_____ 6.0 CONTROL BANK A (CBA)

6.1 Have OATC to select CBA on "CRD BANK SELECT"

6.2 Verify that only "GRP SELECT" light "A" is illuminated on Rod Control Power Cabinets 1AC and 2AC.

_____ 7.0 CONTROL BANK B (CBB)

7.1 Have OATC to select CBB on "CRD BANK SELECT"

ENCLOSURE 13.10
ROD CONTROL CABINET
GROUP SELECT LIGHT CHECKOUT

7.2 Verify that only "GRP SELECT" light "A" is illuminated on Rod Control Power Cabinets 1BD and 2BD.

____ 8.0 CONTROL BANK C (CBC)

8.1 Have OATC to select CBC on "CRD BANK SELECT"

8.2 Verify that only "GRP SELECT" light "B" is illuminated on Rod Control Power Cabinets 1AC and 2AC.

____ 9.0 CONTROL BANK D (CBD)

9.1 Have OATC to select CBD on "CRD BANK SELECT"

9.2 Verify that only "GRP SELECT" light "B" is illuminated on Rod Control Power Cabinet 1BD and 2BD.

____ 10.0 IF any expected response is not received, contact Work Control Shift Work Manager to have E Work Order generated for troubleshoot/repair.

Performed By ______________________________ Date ____________

Verified By ______________________________ Date ____________

APPENDIX B

Original Issue NRC SER

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D C. 20555

MAY 22 1987

Docket Nos.: 50-369, 50-370
50-413, 50-414

Mr. H. B. Tucker, Vice President
Nuclear Production Department
Duke Power Company
422 South Church Street
Charlotte, North Carolina 28242

Dear Mr. Tucker:

Subject: ROD SWAP METHODOLOGY REPORT FOR STARTUP PHYSICS TESTING, MCGUIRE AND CATAWBA NUCLEAR STATIONS, UNITS 1 AND 2 (TACs 62981, 62982, 62983, 62984)

By letter dated December 4, 1986, you submitted a report titled "Rod Swap Methodology Report for Startup Physics Testing," and you submitted additional information by letters dated February 11 and March 11, 1987. In addition, telephone discussions were held on May 1, 1987 with members of your company regarding conditions associated with our approval.

We have reviewed the material submitted and find the rod swap methodology as described to be acceptable for rod worth measurement of reloaded cores for McGuire and Catawba Stations, Units 1 and 2. This approval recognizes your prior agreement to certain conditions listed in our enclosed Safety Evaluation Report.

Should you have any questions regarding the enclosure, contact me at (301) 492-8961 or K. Jabbour at (301) 492-7367. In any future correspondence regarding this approval, please include a reference to TACs 62981, 62982, 62983 and 62984.

Sincerely,

Darl Hood

Darl Hood, Project Manager
Project Directorate II-3
Division of Reactor Projects I/II

Enclosure: Safety Evaluation Report

cc w/encl
See next page

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Enclosure

SAFETY EVALUATION REPORT

FOR DUKE POWER COMPANY'S

"ROD SWAP METHODOLOGY REPORT FOR STARTUP PHYSICS TESTING"

Introduction

Duke Power Company (the licensee) submitted a report titled "Rod Swap Methodology Report for Startup Physics Testing" on December 4, 1986. Answers to NRC questions and additional information were submitted by letters dated February 11, 1987 (Ref. 2) and March 11, 1987 (Ref. 3). The report describes the rod swap methodology which Duke Power Company would like to use for rod worth measurement for the McGuire 1 and 2 and the Catawba 1 and 2 units after each reload. While the rod swap technique has been used on Duke plants in the past, the methodology was the Westinghouse methodology which NRC approved on May 28, 1983. Due to the complexities of Rod Swap, the May 28, 1983 approval stated that the method was approved for use by Westinghouse only. Thus, it is necessary for Duke to obtain NRC approval before using the Duke Rod Swap methodology.

Background

The reactivity worth of the control rods is measured at the beginning of each cycle. Rod worth measurements are made in order to verify shutdown margin. The measurement conditions are not those used in the accident analysis but comparison of measurement and predicted rod worths for a known set of conditions gives assurance that rod worths and the shutdown margin predicted for the worst conditions are accurate. For reload cores, usually, not all rod banks are measured. Normally, the control banks (approximately 4 banks, worth about half the total worth) are measured.

The traditional method of rod worth measurement is by boron dilution. Starting from an all rods out critical configuration, the bank is inserted a few steps at a time and the reactor is kept critical by diluting the boron concentration. One control bank would be inserted until it is all the way in and then the next bank would be started. A reactivity computer is also used to measure the reactivity change at each position. The reactivity worth of the bank is the sum of all the reactivity changes recorded by the reactivity computer. The worth of the bank is also equal to the difference in boron concentrations from the bank fully withdrawn to fully inserted positions.

Several years ago an alternative method of rod worth measurement called rod swap or rod exchange was proposed. In this method the highest worth bank, called the reference bank, is measured by boron dilution and remaining banks, called test banks, are measured by "swapping" the test bank with the reference bank. The critical position of each measurement is the reference bank position when the test bank is fully inserted. This method is an indirect method in that it does not measure the worth of banks in combination (i.e. banks D + C + B + A). Rod Swap does have some advantages over boron dilution, however. It does not require the large change in boron concentration and subsequent processing of thousands of gallons of water. It is less time consuming and thus all banks can be measured in much less time than it would take to measure one half the banks by boron dilution.

Evaluation

The Duke Report presents a minimal description of the methodology and a comparison of calculated and inferred worths for several cycles on McGuire 1 and 2. Additional information supplied more details of the procedure. The Duke methodology is very similar to the methodology NRC approved for use by Westinghouse. Duke will use previously approved physics codes and methodologies as described in Reference 4 for the calculations of rod worths and critical heights.

As verification of the methodology, Duke supplied rod swap data for 5 cycles (McGuire Unit 1, Cycles 2, 3 and and 4, McGuire Unit 2, Cycles 2 and 3). This data compares measured and predicted worth for each bank. In addition we have made comparisons of this data with that presented in the Startup Reports for these cycles. (This data is different since Westinghouse did the calculations for these cycles). Examination of the data reveals that the greatest deviation on any one bank was 103 pcm or 24% on a small bank. The greatest deviation on the total worth was 6.9% for Unit 2, Cycle 2. The average total difference was 4.94% which compares favorably with the 6.38% for the Westinghouse predictions.

While for some of the McGuire data the difference between measurement and prediction is greater than usually seen, it is still within the acceptable range. Duke did not perform a side-by-side comparison of boron dilution and rod swap for the same cycle. However, Duke supplied data from the initial startup of Catawba 1 and 2, Catawba 1 using boron dilution and Catawba 2 using Rod Swap. The cores are essentially identical as confirmed by as built parameters and other physics test measurements. The rod worth measurements were within acceptable limits.

Based on our review of the material submitted, we find the rod swap methodology as proposed by Duke Power Company to be acceptable subject to the following conditions, to which Duke Power Company has agreed:

1) The boron dilution rate for measurement of the reference bank shall not exceed 500 pcm.

2) All banks, both control and shutdown banks, must be measured.

3) The review criteria are:

   A. The absolute value of the percent difference between measured and predicted integral worth for the reference bank is $\leq$ 10 percent.

   B. For all banks other than the reference bank, either (whichever is greater);

      1) the absolute value of the percent difference between inferred and predicted integral worths is $\leq$ 15 percent or

2) the absolute value of the reactivity difference between inferred and predicted integral worths is $\leq$ 100 pcm.*

C. The sum of the measured/inferred worth of all the rods must be $\leq$ 110 percent of the predicted worth.

4) The acceptance criteria are:

(1) The sum of the measured/inferred worth of all the rods must be $\geq$ 90 percent of the predicted rod worth.

(2) For all banks other than the reference bank, either (whichever is greater)
a) the absolute value of the percent difference between inferred and predicted integral worth is $<$ 30 percent or
b) the absolute value of the reactivity difference between inferred and predicted integral worths is $<$ 200 pcm.

(3) The absolute value of the percent difference between measured and predicted integral worth for the reference bank is $<$ 15 percent.

5) Additional testing is required if the reference bank boron concentrations and reactivity computer worth do not agree. Remedial action for failure of an acceptance or review criterion require investigation and solution within 30 days (for acceptance criterion) or 60 days (for review criterion). The licensee must then submit a report of the findings to the NRC within 45 days of the test (for acceptance criterion) or within 75 days of the test (for review criterion).

*A pcm is equal to 10^{-5} $\Delta k/k$.

REFERENCES

1) Letter, H. B. Tucker, Duke Power Company, to Harold R. Denton, NRC, December 4, 1986.

2) Letter, H. B. Tucker, Duke Power Company, to Nuclear Regulatory Commission, Document Control Desk, dated February 11, 1987.

3) Letter, H. B. Tucker, Duke Power Company, to Nuclear Regulatory Commission, Document Control Desk, dated March 11, 1987.

4) Duke Power Company, "Nuclear Physics Methodology for Reload Design," DPC-NF-2010A, June 1985.

Mr. H. B. Tucker
Duke Power Company

Catawba Nuclear Station

cc:

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McGuire Nuclear Station

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APPENDIX C

Revision 1 NRC SER

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001
October 1, 2002

Mr. H. B. Barron
Vice President, McGuire Site
Duke Energy Corporation
12700 Hagers Ferry Road
Huntersville, NC 28078-8985

SUBJECT: McGUIRE NUCLEAR STATION, UNITS 1AND 2 RE: ISSUANCE OF AMENDMENTS (TAC NOS. MB3222 AND MB3223)

Dear Mr. Barron:

The Nuclear Regulatory Commission has issued the enclosed Amendment No. 208 to Facility Operating License NPF-9 and Amendment No. 189 to Facility Operating License NPF-17 for the McGuire Nuclear Station, Units 1 and 2. The amendments consist of changes to the Technical Specifications in response to your application dated October 7, 2001, as supplemented by letter dated August 7, 2002.

The amendments revise TS 5.6.5.a by adding a few parameter limits currently included in the Core Operating Limits Report. In addition to the license amendment request, you also submitted revisions to four previously approved topical reports for the Nuclear Regulatory Commission staff review and approval. The enclosed Safety Evaluation also addresses these topical reports.

A Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

Robert Martin

Robert E. Martin, Senior Project Manager, Section 1
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-369 and 50-370

Enclosures:
1. Amendment No. 208 to NPF-9
2. Amendment No. 189 to NPF-17
3. Safety Evaluation

cc w/encls: See next page

McGuire Nuclear Station

cc:

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 208 TO FACILITY OPERATING LICENSE NPF-9

AND AMENDMENT NO. 189 TO FACILITY OPERATING LICENSE NPF-17

DUKE ENERGY CORPORATION

MCGUIRE NUCLEAR STATION, UNITS 1 AND 2

DOCKET NOS. 50-369 AND 50-370

1.0 INTRODUCTION

By letter dated October 7, 2001, as supplemented by letter dated August 7, 2002, Duke Power Company, et al. (DPC, the licensee), submitted a request for changes to the McGuire Nuclear Station, Units 1 and 2, Technical Specifications (TS).

Revisions were proposed for TS 5.6.5.a, Item 1, to add the moderator temperature coefficient (MTC) 60 parts per million (ppm) surveillance limit. The specific value of the surveillance limit was previously relocated to the Core Operating Limits Report (COLR). A new item 12, "31 EFPD surveillance penalty factors for Specifications 3.2.1 and 3.2.2," is also proposed to be added to TS 5.6.5.a.

The initial submittal, dated October 7, 2001, proposed to change the dates and revision numbers for three of the Nuclear Regulatory Commission (NRC) approved analytical methods previously listed in TS 5.6.5.b, as listed below. The changes would reflect later versions of these topical reports that were also submitted with the October 7, 2001, submittal for NRC review and approval. As required by TS 5.6.5.b, only those methods listed within the TS as having been reviewed and approved by the NRC, can be used to determine the subject core operating limits. The subject core operating limits are listed in TS 5.6.5.a and their values are located in the COLR. A revision to a fourth report, DPC-NE-1003, was also submitted for NRC review and approval.

- DPC-NE-2009, Revision 1, "Duke Power Company Westinghouse Fuel Transition Report," August 2001.

- DPC-NF-2010, Revision 1, "Duke Power Company McGuire Nuclear Station and Catawba Nuclear Station Nuclear Physics Methodology for Reload Design," August 2001.

- DPC-NE-2011, Revision 1, "Duke Power Company Nuclear Design Methodology Report for Core Operating Limits of Westinghouse Reactors," August 2001.

- DPC-NE-1003, Revision 1, "McGuire Nuclear Station and Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testing," August 2001.

The licensee in its letter of October 7, 2001, stated that, once approved, the approved topical report revisions, except for DPC-1003, Revision 1, will be listed in Section 5.6.5.b of the McGuire TS, to replace their respective original versions, and that the approved version of DPC-NE-2011-P, Revision 1, will also be listed in the references for TS Bases 3.2.1 and 3.2.3 to replace the existing reference to the original version, DPC-NE-2011-P-A.

However, on July 10, 2002, the NRC issued amendments numbered 203 and 184 to the McGuire Unit 1 and 2 operating licenses that effectively relocated the topical report revision numbers and dates from the TS 5.6.5.b list of approved methodologies to the COLR. Amendments 203 and 184 were consistent with the NRC Technical Specification Task Force (TSTF) Standard TS Traveler TSTF-363, "Revise Topical Report References in ITS 5.6.5 COLR." Accordingly, since this portion of its request is no longer needed in view of amendments 203 and 184, the licensee's letter dated August 7, 2002, eliminated the requests to change TS 5.6.5.b and proposed revisions to BASES 3.2.1 and 3.2.3 to make its submittal consistent with the implementation of amendments 203 and 184 at the McGuire Nuclear Station. Nonetheless, this Safety Evaluation sets forth the NRC staff's evaluation of the licensee's proposed changes to the topical reports listed above.

2.0 BACKGROUND

Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.36 (c)(2)(ii)(B), Criterion 2, specifies that a process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier must be included in the TS limiting conditions for operation (LCO). Accordingly, the reactor operating parameters, which are the initial conditions for the safety analyses of the design basis transients and accidents, are included in the TS LCOs.

Since many parameter limits, such as core physics parameters, generally change with each reload core, licensees previously needed to request TS amendments to update these parameters for each refueling cycle. NRC Generic Letter (GL) 88-16 (Ref. 4) provides guidance for relocating the values of the cycle-specific core operating parameter limits from TS to the COLR, thus eliminating unnecessary burden on the licensees and the NRC to update these limits in the TS for each fuel cycle. The guidance includes adding the COLR in the TS administrative reporting requirement that also specifies (1) the cycle-specific parameters included in the COLR, and (2) the analytical methods that the NRC has previously reviewed and approved to be used to determine the core operating parameters limits.

The McGuire TS 5.6.5, "Core Operating Limits Report (COLR)," conforms to GL 88-16 guidance. TS 5.6.5.a lists a set of parameters, including the reference to the actual TS number for each specified parameter. TS 5.6.5.b specifies the topical reports that are used for the determination of the core operating limits.

The proposed TS changes in this license amendment request are to revise the parameters listed in TS 5.6.5.a. These revisions are based on the guidance of GL 88-16.

3.0 STAFF EVALUATION

In this section, the staff will discuss the review of the revised versions of the four previously approved topical reports submitted for staff review, and the proposed TS changes.

3.1 Topical Reports Revisions

The licensee requested the NRC to review revisions to four topical reports that were previously approved and listed in TS 5.6.5.b as the approved methodologies used for the determination of the parameter limits in the COLR. Since the staff has reviewed and approved the original versions of these topical reports, the staff review of these revised versions concentrated on the revisions made to the approved reports.

3.1.1 DPC-NE-2009, Revision 1

Topical report, DPC-NE-2009-P-A, (Ref. 5), provides general information about the Robust Fuel Assembly (RFA) design and describes methodologies used for reload design analyses to support the licensing basis for use of RFAs in the McGuire and Catawba reload cores. These methodologies include fuel rod mechanical reload analysis methodology and the core design, thermal-hydraulic analysis, and accident analysis methodologies. The NRC approved the report in September 1999.

Revision 1 of DPC-NE-2009, as amended by the August 7, 2002, letter (Ref. 2), consists of the following minor changes to its Chapter 6, "UFSAR Accident Analyses."

(A) Update of the reference list in Section 6.7 as follows:

- Update reference 6-25, WCAP-10054-P-A Addendum 2, to Revision 1, dated July 1997.
- Correct reference 6-35, WCAP-8354, with proprietary topical report number, and designate the second report as a non-proprietary report.
- Add reference 6-39, Westinghouse letter NSD-NRC-99-5839, "1998 Annual Notification of Changes to the Westinghouse Small Break LOCA and Large Break LOCA ECCS Evaluation Models, Pursuant to 10 CFR 50.46(a)(3)(ii)," dated July 15, 1999 (Ref. 6).

(B) Addition of a paragraph to Section 6.5.1, "Small Break LOCA," to explain that the Westinghouse small break LOCA NOTRUMP Evaluation Model includes the error corrections and model enhancements described in a few Westinghouse annual notifications required by 10 CFR 50.46, including the 1998 annual notification referenced in Reference 39.

The first two changes in the reference list are editorial and merely provide the latest version of the approved topical report or identify the proprietary and non-proprietary versions of a topical report. Reference 6-39, Westinghouse letter NSD-NRC-99-5839, is the annual notification of the changes to the LOCA evaluation models during 1998. This notification documented the following error corrections or model enhancements to the NOTRUMP small break LOCA Evaluation Model:

- A programming error correction on the SBLOCTA rod-to-rod radiation model, that is not modeled in licensing basis analyses and therefore, has no impact on the small break LOCA results.

- A logic simplification to the NOTRUMP droplet fall model that produces insignificant differences in results.

- A change in the reactor coolant pump heat in NOTRUMP that is not used in the evaluation model and therefore, has no impact on the small break LOCA results.

- A modification of NOTRUMP steam generator tube condensation heat transfer logic for a foreign plant that does not affect standard Westinghouse Pressurized Water Reactor calculations.

- An extension of reactor coolant conditions to allow for the NOTRUMP point kinetics calculations to be performed for cases that experience core uncovery conditions prior to reactor trip. For typical small break LOCA analyses, the reactor trips long before any threat of core uncovery and therefore, the change has no impact on peak cladding temperature calculations.

- A programming change in SBLOCTA code to allow for modeling of variable length blankets on either ends of the rod that involves no changes to the thermal-hydraulic fuel rod model, nor the solution technique.

Since the changes documented in the Westinghouse annual notice have insignificant impact on the small break LOCA analyses, the staff concludes the addition of Reference 6-39 is acceptable. Therefore, Revision 1 of DPC-NE-2009-P-A, as modified in the August 7, 2002, letter, is acceptable.

3.1.2 DPC-NF-2010, Revision 1

Topical Report DPC-NF-2010, (Ref. 7), describes DPC's Nuclear Design Methodology for McGuire and Catawba Nuclear Stations. The nuclear design process consists of mechanical properties used as nuclear design input, the nuclear code system and methodology that DPC intends to use to perform design calculations and to provide operational support, and the development of statistical factors.

Revision 1 of DPC-NF-2010, updates the report to permit the use of certain methods approved subsequent to the implementation of the original version, such as the use of CASMO-3/ SIMULATE-3P reactor physics methods (Ref. 8). Other changes are made to reflect revisions to the core design parameters such as shutdown margin, boron and control rod worth, axial and radial peaking factors, and cycle length, as well as numerous editorial changes.

During the review, the staff also identified a few discrepancies associated with administrative changes. In response to the staff's request for additional information (Ref. 2), the licensee provided further changes to Revision 1 of the topical report. These modifications include clarifications to revised sections and minor changes to equations. The NRC staff has reviewed the analyses associated with the changes to Topical Report DPC-NF-2010 and the responses to the requests for additional information pertaining to these changes. The staff has concluded that the changes to this topical report consist mostly of administrative changes and clarifications to the original NRC approved topical report and that there are no unreviewed methodology or regulatory issues. Therefore, the staff finds the changes to be acceptable.

3.1.3 DPC-NE-2011, Revision 1

Topical Report DPC-NF-2011, (Ref. 9), describes the methodology for performing a maneuvering analysis for four-loop plants, such as the McGuire and Catawba Nuclear Stations. The licensee has developed this methodology as an alternate to the existing Relaxed Axial Offset Control (RAOC) Methodology. The licensee pointed out that this maneuvering analysis results in several advantages: more flexible and prompt engineering support for the operating stations, consistency with the methods of the licensee's nuclear design process, and potential increases in available margin through the use of three-dimensional monitoring techniques. The increase in margin occurs in limits on power distribution, control rod insertion, and power distribution inputs to the overpower delta-temperature and over-temperature delta-temperature reactor protection system (RPS) trip functions.

Revision 1 of DPC-NE-2011, updates the report to include editorial changes, and to permit the use of certain methods approved subsequent to the implementation of the original version, such as the CASMO-3/SIMULATE-3P methodology (Ref. 8). Other changes are made to reflect revisions to the core design parameters such as power peaking factors, axial and radial power distributions, and cycle length, as well as numerous editorial changes.

In response to the NRC staff's request for additional information (Ref. 2), the licensee provided additional information regarding cycle depletion times to clarify issues associated with power peaking versus burnup as a function of cycle time. The licensee's amendment request also included clarifications to revised sections and minor changes to equations. The NRC staff has reviewed the analyses associated with the changes to Topical Report DPC-NE-2011-A and the responses to the requests for additional information pertaining to the requested changes. Since the changes to this topical report consist mostly of administrative changes and clarifications to the original NRC approved topical report, the staff finds the changes to be acceptable.

3.1.4 DPC-NE-1003, Revision 1

Topical Report DPC-NE-1003 (Ref. 10), describes the measurement procedure used to determine the inferred bank worth and the calculation procedures used to develop the rod swap correction factor that accounts for the effect of a test bank on the partial integral worth of the reference bank. The NRC approved the report in May 1987 (Ref. 11) for rod worth measurement of reload cores for McGuire and Catawba Stations, Units 1 and 2.

Revision 1 of DPC-NE-1003 updates the report to permit the use of certain methods approved subsequent to the implementation of the original version, such as the use of CASMO-3/ SIMULATE-3P reactor physics methods (Ref. 8). Other changes are made to reflect the revision of the rod swap measurement procedures, and various editorial changes. In response to staff questions, the licensee, in its letter of August 7, 2002, provided the current version of the control rod worth measurement rod swap procedures, PT/0/A/4150/11A, dated January 19, 1996. The staff review of this current control rod worth measurement procedure has found it to be acceptable. The licensee, in the August 7, 2002, letter also modified the equation in Section 3 of the topical report for the calculation of the inferred rod bank worth from the measured reference bank worth and bank height. This change is consistent with the equation described in step 12.12.5 of the current measurement procedures of January 19, 1996. Therefore, Revision 1 of DPC-NE-1003, as modified in the August 7, 2002, letter, is acceptable.

3.2 Proposed TS Changes

This section addresses the staff's evaluation of the proposed changes to TS 5.6.5.a regarding the cycle-specific operating parameters specified in the COLR. The staff review of these TS changes are based on the guidance of GL 88-16.

TS 5.6.5.a provides a list of core operating limits that are established prior to each reload cycle, or prior to any remaining portion of a reload cycle. The values of the limits are located in the COLR. For McGuire Nuclear Station, Units 1 and 2, the licensee proposed to revise the list by:

(1) adding "60 ppm" to Item 5.6.5.a.1 regarding the moderator temperature coefficient (MTC) surveillance limit for Specification 3.1.3, and

(2) adding Item 5.6.5.a.12, "31 EFPD surveillance penalty factors for Specifications 3.2.1 and 3.2.2."

These changes are evaluated below.

3.2.1 MTC 60 ppm Surveillance Limit

McGuire TS LCO 3.1.3 specifies that the MTC be maintained within the LCO limits, which are based on the safety analysis assumptions. For verification that these LCO limits are met, the Surveillance Requirements of TS 3.1.3 also place surveillance limits for conducting the end of cycle MTC measurement at boron concentrations of 300 ppm and 60 ppm. The LCO limits and the 300 ppm and 60 ppm surveillance limits are specified in the COLR. However, TS Item 5.6.5.a.1 operating limits does not currently identify the 60-ppm surveillance limit.

The proposed change to the McGuire TS would add the 60 ppm surveillance limit in Item 5.6.5.a.1. The new TS would read "Moderator Temperature Coefficients BOL and EOL limits and 60 ppm and 300 ppm surveillance limit for Specification 3.1.3." The NRC approved incorporating the 60-ppm surveillance limits into the COLR during the Improved Technical Specifications conversion in 1998 (Ref. 12 and 13); however, reference to this surveillance was not included in TS Item 5.6.5.a.1 at that time. The proposed TS change to include the 60 ppm surveillance limit in TS Item 5.6.5.a.1 provides consistency with previously approved requirements and, therefore, it is acceptable.

3.2.2 Relocation of Hot Channel Factors Surveillance Penalty Factors to COLR

Surveillance Requirements in TS 3.2.1 and 3.2.2, respectively, require that the heat flux hot channel factor, F_q (x,y,z), and the enthalpy rise hot channel factor, $F_{\Delta h}$ (x,y), be measured every 31 effective full power days (EFPD) during equilibrium conditions using the incore detector system to verify they are within the respective limits. To address the possibility that these hot channel factors may increase and exceed their allowable limits between surveillances, penalty factors are applied to these hot channel factors if their margins to the respective limits have decreased since the previous surveillance. These margin-decrease penalty factors are calculated by projecting the limiting hot channel factors over the 31 EFPD surveillance intervals with the maximum changes at the limiting core location, and are based on reload core design. In Section 8, "Improved Technical Specification Changes," of DPC-NE-2009, the licensee proposed to replace the penalty factors with tables of penalty value as a function of burnup in the COLR to facilitate cycle-specific updates. TS Item 5.6.5.b.14 lists topical report DPC-NE-2009-P-A that includes (in response to a staff question during the review of DPC-NE-2009) the approved methodology used to calculate these burnup-dependent penalty factors. The staff found the methodology and the inclusion of the burnup-dependent margin decrease penalty factors in the COLR acceptable, as stated in the staff's Safety Evaluation supporting license Amendment Nos. 188 and 169, respectively, for McGuire Nuclear Station, Units 1 and 2 (Ref. 14).

The proposed changes to the McGuire TS would add Item 5.6.5.a.12 that reads: "31 EFPD surveillance penalty factors for Specifications 3.2.1 and 3.2.2." The addition of TS Item 5.6.5.a.12 would make it consistent with the previous staff approval of including these surveillance penalty factors in the COLR and, therefore, this proposed change is acceptable.

4.0 SUMMARY

The staff has reviewed the revisions to four previously approved topical reports described in Section 1.0 of this Safety Evaluation, and the proposed changes to McGuire Nuclear Station, Units 1 and 2, TS 5.6.5.a related to the COLR. Based on our evaluation, described in Section 3 of this Safety Evaluation, the staff concludes that the these topical report revisions, as amended by the August 7, 2002, letter, and the TS changes are acceptable.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the North Carolina State official was notified of the proposed issuance of the amendments. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

The amendments change recordkeeping, reporting, or administrative procedure requirements with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts and no significant change in the types of any effluents that may be released offsite and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding (67FR 54680). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

8.0 REFERENCES

1. Letter from M. S. Tuckman, Duke Energy Corporation, to US Nuclear Regulatory Commission, "Duke Energy Corporation; Catawba Nuclear Station Units 1 and 2, Docket Nos. 50-413, 50-414; McGuire Nuclear Station Units 1 and 2, Docket Nos. 50-369, 50-370; License Amendment Request Applicable to Technical Specifications 5.6.5, Core Operating Limits Report; Revisions to BASES 3.2.1 and 3.2.3; and Revisions to Topical Reports DPC-NE-2009-P, DPC-NF-2010, DPC-NE-2011-P, and DPC-NE-1003," October 7, 2001.

2. Letter from M. S. Tuckman, Duke Energy Corporation, to US Nuclear Regulatory Commission, "Duke Energy Corporation; McGuire Nuclear Station Units 1 and 2, Docket Nos. 50-369 and 370; Catawba Nuclear Station Units 1 and 2, Docket Nos. 50-413 and 414; Response to NRC Request for Additional Information - TAC nos. MB3222, MB3223, MB3343 and MB3344) and License Amendment Request Supplement," August 7, 2002.

3. Letter from M. S. Tuckman, Duke Energy Corporation, to US Nuclear Regulatory Commission, "License Amendment Request Applicable to the Technical Specifications Requirements for the Core Operating Limits Report - Oconee, McGuire, and Catawba Technical Specifications 5.6.5," December 20, 2001.

4. Letter from Dennis Crutchfield, USNRC, to All Power Reactor Licensees and Applicants, "Removal of Cycle-Specific Parameter Limits from Technical Specifications (Generic Letter 88-16)," October 4, 1988.

5. DPC-NE-2009-P-A, "Duke Power Company Westinghouse Fuel Transition Report," December 1999.

6. Letter from J. S. Galembush, Westinghouse Electric Company, to US Nuclear Regulatory Commission, "1998 Annual Notification of Changes to the Westinghouse Small Break LOCA and Large Break LOCA ECCS Evaluation Models, Pursuant to 10 CFR 50.46(a)(3)(ii)," NSD-NRC-99-5839, July 15, 1999.

7. DPC-NF-2010A, "Duke Power Company McGuire Nuclear Station and Catawba Nuclear Station Nuclear Physics Methodology for Reload Design," June 1985..

8. DPC-NE-1004A, Revision 1, "Nuclear Design Methodology Using CASMO-3/ SIMULATE-3P," SER dated April 26, 1997.

9. DPC-NE-2011, "Nuclear Design Methodology Report for Core Operating Limits of Westinghouse Reactors," March 1990.

10. DPC-NE-1003, "Rod Swap Methodology Report for Startup Physics Testing," December 1986.

11. Letter from Darl Hood, USNRC, to H. B. Tucker, Duke Power Company, "Rod Swap Methodology Report for Startup Physics Testing, McGuire and Catawba Nuclear Stations, Units 1 and 2 (TACs 62981, 62982, 62983, 62984)," May 22, 1987.

12. Letter from Frank Rinaldi, USNRC, to H. B. Brown, McGuire Site, Duke Energy Corporation, "Issuance of Amendments - McGuire Nuclear Station, Units 1 and 2, (TAC Nos. M98964 and M98965)," September 30, 1998.

13. Letter from Peter Tam, USNRC, to G. R. Peterson, Catawba Nuclear Station, Duke Energy Corporation, "Issuance of Amendments - Catawba Nuclear Station, Units 1 and 2 (TAC Nos. M95298 and M95299)," September 30, 1998.

14. Letter from Frank Rinaldi, USNRC, to H. B. Brown, McGuire Site, Duke Energy Corporation, "McGuire Nuclear Station, Units 1 and 2, Re: Issuance of Amendments (TAC Nos. MA2411 and MA2412)," September 22, 1999.

15. Letter from Peter Tam, USNRC, to G. R. Peterson, Catawba Nuclear Station, Duke Energy Corporation, "Catawba Nuclear Station, Units 1 and 2, Re: Issuance of Amendments (TAC Nos. MA2359 and MA2361)," September 22, 1999.

16. Letter from Robert F. Martin, USNRC, to David L. Rehn, Catawba Site, Duke Power Company, "Issuance of Amendments - Catawba Nuclear Station, Units 1 and 2 Cycle Specific Parameters to the Core Operating Limits Report (TAC Nos. M85472 and M85473)," March 25, 1994.

Principal Contributor: Y. Hsii
A. Attard

Date: October 1, 2002

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

RECEIVED
OCT - 8 2002
REGULATORY COMPLIANCE

October 1, 2002

Mr. G. R. Peterson
Site Vice President
Catawba Nuclear Station
Duke Energy Corporation
4800 Concord Road
York, South Carolina 29745-9635

SUBJECT: CATAWBA NUCLEAR STATION, UNITS 1 AND 2 RE: ISSUANCE OF AMENDMENTS (TAC NOS. MB3343 AND MB3344)

Dear Mr. Peterson:

The Nuclear Regulatory Commission has issued the enclosed Amendment No. 202 to Facility Operating License NPF-35 and Amendment No.195 to Facility Operating License NPF-52 for the Catawba Nuclear Station, Units 1 and 2. The amendments consist of changes to the Technical Specifications (TS) in response to your application dated October 7, 2001, as supplemented by letter dated August 7, 2002.

The amendments revise TS 5.6.5.a by adding a few parameter limits currently included in the Core Operating Limits Report. In addition to the license amendment request, you also submitted revisions to four previously approved topical reports for the Nuclear Regulatory Commission staff review and approval. The enclosed Safety Evaluation also address these topical reports.

A Notice of Issuance will be included in the Commission's biweekly Federal Register notice.

Sincerely,

Chandu P. Patel

Chandu P. Patel, Project Manager, Section 1
Project Directorate II /RA/
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-413 and 50-414

Enclosures:
1. Amendment No. 202 to NPF-35
2. Amendment No. 195 to NPF-52
3. Safety Evaluation

cc w/encls: See next page

Catawba Nuclear Station

cc:

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 202 TO FACILITY OPERATING LICENSE NPF-35

AND AMENDMENT NO. 195 TO FACILITY OPERATING LICENSE NPF-52

DUKE ENERGY CORPORATION, ET AL.

CATAWBA NUCLEAR STATION, UNITS 1 AND 2

DOCKET NOS. 50-413 AND 50-414

1.0 INTRODUCTION

By letter dated October 7, 2001, as supplemented by letter dated August 7, 2002, Duke Energy Corporation, et al. (DEC, the licensee), submitted a request for changes to the Catawba Nuclear Station, Units 1 and 2, Technical Specifications (TS).

Revisions were proposed for TS 5.6.5.a, Item 1, to add the moderator temperature coefficient (MTC) 60 parts per million (ppm) surveillance limit. The specific value of the surveillance limit was previously relocated to the Core Operating Limits Report (COLR). Two new items were also proposed to be added to TS 5.6.5.a. These two items are (1) Item 12, "31 EFPD surveillance penalty factors for Specifications 3.2.1 and 3.2.2," and (2) Item 13, "Reactor makeup water pumps combined flow rates limit for Specifications 3.3.9 and 3.9.2."

The initial submittal, dated October 7, 2001, proposed to change the dates and revision numbers for three of the Nuclear Regulatory Commission (NRC) approved analytical methods previously listed in TS 5.6.5.b, as listed below. The changes would reflect later versions of these topical reports that were also submitted with the October 7, 2001, submittal for NRC review and approval. As required by TS 5.6.5.b, only those methods listed within the TS as having been reviewed and approved by the NRC, can be used to determine the subject core operating limits. The subject core operating limits are listed in TS 5.6.5.a and their values are located in the COLR. A revision to a fourth report, DPC-NE-1003, was also submitted for NRC review and approval.

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- DPC-NE-2011, Revision 1, "Duke Power Company Nuclear Design Methodology Report for Core Operating Limits of Westinghouse Reactors," August 2001.

- DPC-NE-1003, Revision 1, "McGuire Nuclear Station and Catawba Nuclear Station Rod Swap Methodology Report for Startup Physics Testing," August 2001.

The licensee in its letter of October 7, 2001, stated that, once approved, the approved topical report revisions, except for DPC-1003, Revision 1, will be listed in Section 5.6.5.b of the Catawba TS, to replace their respective original versions, and that the approved version of DPC-NE-2011-P, Revision 1, will also be listed in the references for TS Bases 3.2.1 and 3.2.3 to replace the existing reference to the original version, DPC-NE-2011-P-A.

However, on July 2, 2002, the NRC issued amendments numbered 199 and 192 to the Catawba Unit 1 and 2 operating licenses that effectively relocated the topical report revision numbers and dates from the TS 5.6.5.b list of approved methodologies to the COLR. Amendments 199 and 192 were consistent with the NRC Technical Specification Task Force (TSTF) Standard TS Traveler TSTF-363, "Revise Topical Report References in ITS 5.6.5 COLR." Accordingly, since this portion of its request is no longer needed in view of amendments 199 and 192, the licensee's letter dated August 7, 2002, eliminated the requests to change TS 5.6.5.b and proposed revisions to BASES 3.2.1 and 3.2.3 to make its submittal consistent with the implementation of amendments 199 and 192 at the Catawba Nuclear Station. Nonetheless, this Safety Evaluation sets forth the NRC staff's evaluation of the licensee's proposed changes to the topical reports listed above.

2.0 BACKGROUND

Title 10 of the *Code of Federal Regulation* (10 CFR) Section 50.36 (c)(2)(ii)(B), Criterion 2 specifies that a process variable, design feature, or operating restriction that is an initial condition of a design basis accident or transient analysis that either assumes the failure of or presents a challenge to the integrity of a fission product barrier must be included in the TS limiting conditions for operation (LCO). Accordingly, the reactor operating parameters, which are the initial conditions for the safety analyses of the design basis transients and accidents, are included in the TS LCO.

Since many parameters limits, such as core physics parameters, generally change with each reload core, licensees need to request TS amendments to update these parameters for each refueling cycle. NRC Generic Letter (GL) 88-16 (Ref. 4) provides guidance for relocating the values of the cycle-specific core operating parameter limits from TS to the COLR, and thus eliminates the unnecessary burden on the licensees and the NRC to update these limits in the TS each fuel cycle. The guidance includes adding the COLR in the TS administrative reporting requirement that also specifies (1) the cycle-specific parameters included in the COLR, and (2) the analytical methods that the NRC has previously reviewed and approved to be used to determine the core operating parameters limits.

The Catawba TS 5.6.5, "Core Operating Limits Report (COLR)," conforms to the GL 88-16 guidance. TS 5.6.5.a lists a set of parameters, including the reference to the actual TS number for each specified parameter. TS 5.6.5.b specifies the topical reports that are used for the determination of the core operating limits.

The proposed TS changes in this license amendment request are to revise the parameters listed in TS 5.6.5.a. These revisions are based on the guidance of GL 88-16.

3.0 STAFF EVALUATION

In this section, the staff will discuss the review of the revised versions of the four previously approved topical reports submitted for staff review, and the proposed TS changes.

3.1 Topical Reports Revisions

The licensee requested the NRC to review revisions of four topical reports that were previously approved and listed in TS 5.6.5.b as the approved methodologies used for the determination of the parameter limits in the COLR. Since the staff has reviewed and approved the original versions of these topical reports, the staff review of these revised versions will concentrate on the revisions made to the approved reports.

3.1.1 DPC-NE-2009, Revision 1

Topical report, DPC-NE-2009-P-A, (Ref. 5), provides general information about the Robust Fuel Assembly (RFA) design and describes methodologies used for reload design analyses to support the licensing basis for use of the RFA design in the McGuire and Catawba reload cores. These methodologies include fuel rod mechanical reload analysis methodology and the core design, thermal-hydraulic analysis, and accident analysis methodologies. The NRC approved the report in September 1999.

Revision 1 of DPC-NE-2009-A, as amended by the August 7, 2002, letter (Ref. 2), consists of the following minor changes to Chapter 6, "UFSAR Accident Analyses:"

(A) Update of the reference list in Section 6.7 as follows:

- Update reference 6-25, WCAP-10054-P-A Addendum 2, to Revision 1, dated July 1997.
- Correct reference 6-35, WCAP-8354, with proprietary topical report number, and designate the second report as a non-proprietary report.
- Add reference 6-39 a Westinghouse letter NSD-NRC-99-5839, "1998 Annual Notification of Changes to the Westinghouse Small Break LOCA and Large Break LOCA ECCS Evaluation Models, Pursuant to 10 CFR 50.46(a)(3)(ii)," dated July 15, 1999 (Ref. 6).

(B) Addition of a paragraph to Section 6.5.1, "Small Break LOCA," to explain that the Westinghouse small break LOCA NOTRUMP Evaluation Model includes the error corrections and model enhancements described in a few Westinghouse annual notifications required by 10 CFR 50.46, including the 1998 annual notification referenced in Reference 39.

The first two changes in the reference list are editorial and merely provide the latest version of the approved topical report or identify the proprietary and non-proprietary versions of a topical report. Reference 6-39, the Westinghouse letter NSD-NRC-99-5839, is the annual notification of the changes to the LOCA evaluation models during 1998. This notification documented the following error corrections or model enhancements to the NOTRUMP small break LOCA Evaluation Model:

- A programming error correction on the SBLOCTA rod-to-rod radiation model that is not modeled in licensing basis analyses and therefore, has no impact on the small break LOCA results.

- A logic simplification to the NOTRUMP droplet fall model that produces insignificant differences in results.

- A change in the reactor coolant pump heat in NOTRUMP that is not used in the evaluation model and therefore, has no impact on the small break LOCA results.

- A modification of NOTRUMP steam generator tube condensation heat transfer logic to a foreign plant that does not affect standard Westinghouse Pressurized Water Reactor calculations.

- An extension of reactor coolant conditions to allow for the NOTRUMP point kinetics calculations to be performed for cases that experience core uncovery conditions prior to reactor trip. For typical small break LOCA analyses, the reactor trips long before any threat of core uncovery and therefore, the change has no impact on peak cladding temperature calculations.

- A programming change in SBLOCTA code to allow for modeling of variable length blankets on either ends of the rod that involves no changes to the thermal-hydraulic fuel rod model, nor the solution technique.

Since the changes documented in the Westinghouse annual notice have insignificant impact on the small break LOCA analyses, the staff concludes the addition of Reference 6-39 is acceptable. Therefore, Revision 1 of DPC-NE-2009-P-A, as modified in the August 7, 2002, letter, is acceptable.

3.1.2 DPC-NF-2010A, Revision 1

Topical Report DPC-NF-2010A, (Ref. 7), describes Duke Power Company's Nuclear Design Methodology for McGuire and Catawba Nuclear Stations. The nuclear design process consists of mechanical properties used as nuclear design input, the nuclear code system and methodology the licensee intends to use to perform design calculations and to provide operational support, and the development of statistical factors.

Revision 1 of DPC-NF-2010A, updates the report to permit the use of certain methods approved subsequent to the implementation of the original version, such as the use of CASMO-3/SIMULATE-3P reactor physics methods (Ref. 8). Other changes are made to reflect revisions to the core design parameters such as shutdown margin, boron and control rod worth, axial and radial peaking factors, and cycle length, as well as numerous editorial changes.

During the review, the staff also identified a few discrepancies associated with administrative changes. In response to the staff's request for additional information (Ref. 2), the licensee provided further changes to Revision 1 of the Topical report. These modifications include clarifications to revised sections and minor changes to equations. The NRC staff has reviewed the analyses associated with the changes to Topical Report DPC-NF-2010A and the responses to the requests for additional information pertaining to these changes. The staff has concluded that the changes to this topical report consist mostly of administrative changes and clarifications to the original NRC approved topical report and that there are no unreviewed methodology or regulatory issues. Therefore, the staff finds the changes acceptable.

3.1.3 DPC-NE-2011, Revision 1

Topical Report DPC-NE-2011, (Ref. 9), describes the methodology for performing a maneuvering analysis for four-loop plants, such as McGuire and Catawba Nuclear Station. The licensee has developed this methodology as an alternate to the existing Relaxed Axial Offset Control Methodology. The licensee pointed out that this maneuvering analysis results in several advantages: more flexible and prompt engineering support for the operating stations, consistency with the methods of the licensee's nuclear design process, and potential increases in available margin through the use of three-dimensional monitoring techniques. The increase in margin occurs in limits on power distribution, control rod insertion, and power distribution inputs to the overpower delta-temperature and over-temperature delta-temperature reactor protection system trip functions.

Revision 1 of DPC-NE-2011, updates the report to include editorial changes, and to permit the use of certain methods approved subsequent to the implementation of the original version, such as the use of CASMO-3/SIMULATE-3P methodology (Ref. 8). Other changes are made to reflect revisions to the core design parameters such as power peaking factors, axial and radial power distributions, and cycle length, as well as numerous editorial changes.

In response to the NRC staff's request for additional information (Ref. 2), the licensee provided additional information to the staff regarding cycle depletion times to clarify issues associated with power peaking versus burnup as a function of cycle time. The licensee's amendment request also included clarifications to revised sections and minor changes to equations. The NRC staff has reviewed the analyses associated with the changes to Topical Report DPC-NE-2011-A and the responses to the requests for additional information pertaining to the requested changes. Since the changes to this topical report consists mostly of administrative changes and clarifications to the original NRC approved topical report, the staff find the changes acceptable.

3.1.4 DPC-NE-1003, Revision 1

Topical Report DPC-NE-1003 (Ref. 10) describes the measurement procedure used to determine the inferred bank worth and the calculation procedures used to develop the rod swap correction factor that accounts for the effect of a test bank on the partial integral worth of the reference bank. The NRC approved the report in May 1987 (Ref. 11) for rod worth measurement of reload cores for McGuire and Catawba Stations, Units 1 and 2.

Revision 1 of DPC-NE-1003 updates the report to permit the use of certain methods approved subsequent to the implementation of the original version, such as the use of CASMO-3/ SIMULATE-3P reactor physics methods (Ref. 8). Other changes are made to reflect the revision of the rod swap measurement procedures, and various editorial changes. In response to staff questions, the licensee, in its letter of August 7, 2002, provided the current version of the control rod worth measurement rod swap procedures, PT/0/A/4150/11A, dated January 19, 1996. The staff review of this current control rod worth measurement procedure has found it acceptable. The licensee in the August 7, 2002, letter also modified the equation in Section 3 of the topical report for the calculation of the inferred rod bank worth from the measured reference bank worth and bank height. This change is consistent with the equation described in step 12.12.5 of the current measurement procedures of January 19, 1996. Therefore, Revision 1 of DPC-NE-1003, as modified in the August 7, 2002, letter, is acceptable.

3.2 Proposed TS Changes

This section addresses the staff's evaluation of the proposed changes to TS 5.6.5.a regarding the cycle-specific operating parameters specified in the COLR. The staff review of these TS changes are based on the guidance of GL 88-16.

TS 5.6.5.a provides a list of core operating limits that are established prior to each reload cycle, or prior to any remaining portion of a reload cycle. The valves of the limits are in the COLR. For Catawba Units 1 and 2, the licensee proposed to revise the list by:

(1) adding "60 ppm" to Item 5.6.5.a.1 regarding the moderator temperature coefficient (MTC) surveillance limit for Specification 3.1.3,

(2) adding Item 5.6.5.a.12, "31 EFPD surveillance penalty factors for Specifications 3.2.1 and 3.2.2," and

(3) adding Item 5.6.5.a.13, "Reactor makeup water pumps combined flow rates limit for Specifications 3.3.9 and 3.9.2."

These changes are evaluated below.

3.2.1 MTC 60 ppm Surveillance Limit

Catawba TS LCO 3.1.3 specifies that the MTC be maintained within the LCO limits, which are based on the safety analysis assumptions. For verification that these LCO limits are met, the Surveillance Requirements of TS 3.1.3 also places surveillance limits for conducting the end of cycle MTC measurement at 300 ppm and 60 ppm boron concentration. The LCO limits and the 300-ppm and 60-ppm surveillance limits are specified in the COLR. However, TS Item 5.6.5.a.1 operating limits does not currently identify the 60-ppm surveillance limit.

The proposed change to the Catawba TS would add the 60-ppm surveillance limit in Item 5.6.5.a.1. The new TS would read "Moderator Temperature Coefficients BOL and EOL limits and 60 ppm and 300 ppm surveillance limit for Specification 3.1.3." The NRC approved incorporating the 60-ppm surveillance limits into the COLR during the Improved Technical Specifications conversion in 1998 (Ref. 12 and 13); however, reference to this surveillance was not included in TS Item 5.6.5.a.1 at that time. The proposed TS change to include the 60-ppm surveillance limit in TS Item 5.6.5.a.1 provides consistency with previously approved requirements and, therefore, it is acceptable.

3.2.2 Relocation of Hot Channel Factors Surveillance Penalty Factors to COLR

Surveillance Requirements in TS 3.2.1 and 3.2.2, respectively, require that the heat flux hot channel factor, F_q (x,y,z), and the enthalpy rise hot channel factor, $F_{\Delta h}$ (x,y), be measured every 31 effective full power days (EFPD) during equilibrium conditions using the incore detector system to verify they are within the respective limits. To address the possibility that these hot channel factors may increase and exceed their allowable limits between surveillances, penalty factors are applied to these hot channel factors if their margins to the respective limits have decreased since the previous surveillance. These margin-decrease penalty factors are calculated by projecting the limiting hot channel factors over the 31 EFPD surveillance intervals with the maximum changes at the limiting core location, and are based on reload core design. In Section 8, "Improved Technical Specification Changes," of DPC-NE-2009, the licensee proposed to replace the penalty factors with tables of penalty value as functions of burnup in the COLR to facilitate cycle-specific updates. TS Item 5.6.5.b.14 lists topical report DPC-NE-2009-P-A that includes (in response to a staff question during the review of DPC-NE-2009) the approved methodology used to calculate these burnup-dependent penalty factors. The staff found the methodology and the inclusion of the burnup-dependent margin decrease penalty factors in the COLR acceptable as stated in the staff's safety evaluation supporting license amendment Nos. 180 and 172, respectively for Catawba Units 1 and 2 (Ref. 15).

The proposed changes to the Catawba TS would add Item 5.6.5.a.12, that reads: "31 EFPD surveillance penalty factors for Specifications 3.2.1 and 3.2.2." The addition of TS Item 5.6.5.a.12 would make it consistent with the previous staff approval of including these surveillance penalty factors in the COLR and, therefore, this proposed change is acceptable.

3.2.3 Reactor Makeup Water Pumps Combined Flow Rates Limit

The relocation of the reactor makeup water pumps combined flow rates limit for the boron dilution mitigation system from Catawba TS 3.3.9 and 3.9.2 to the COLR was approved by the NRC as described in a letter dated March 25, 1994 (Ref. 16). The reactor makeup water pumps flow rate limit is included in the Catawba COLR.

The proposed changes to the Catawba TS would add Item 5.6.5.a.13, "Reactor makeup water pumps combined flow rates limit for Specification 3.3.9 and 3.9.2," to TS 5.6.5.a. The addition of this item would make the TS 5.6.5.a list consistent with the core operating limits included in the Catawba COLR and is therefore, acceptable.

4.0 SUMMARY

The staff has reviewed the revisions of four previously approved topical reports described in Section 1.0 of this Safety Evaluation, and the proposed changes to Catawba Nuclear Station, Units 1 and 2, TS 5.6.5.a related to the COLR. Based on our evaluation described in Section 3 of this Safety Evaluation, the staff concludes that the these topical report revisions, as amended by the August 7, 2002, letter, and the TS changes are acceptable.

5.0 STATE CONSULTATION

In accordance with the Commission's regulations, the South Carolina State official was notified of the proposed issuance of the amendments. The State official had no comments.

6.0 ENVIRONMENTAL CONSIDERATION

The amendments change requirements with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts and no significant change in the types of any effluents that may be released offsite and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding [67 FR 54680]. Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

7.0 CONCLUSION

The Commission has concluded, based on the considerations discussed above that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

8.0 REFERENCES

1. Letter from M. S. Tuckman, Duke Energy Corporation, to US Nuclear Regulatory Commission, "Duke Energy Corporation; Catawba Nuclear Station Units 1 and 2, Docket Nos. 50-413, 50-414; McGuire Nuclear Station Units 1 and 2, Docket Nos. 50-369, 50-370; License Amendment Request Applicable to Technical Specifications 5.6.5, Core Operating Limits Report; Revisions to BASES 3.2.1 and 3.2.3; and Revisions to Topical Reports DPC-NE-2009-P, DPC-NF-2010, DPC-NE-2011-P, and DPC-NE-1003," October 7, 2001.

2. Letter from M. S. Tuckman, Duke Energy Corporation, to US Nuclear Regulatory Commission, "Duke Energy Corporation; McGuire Nuclear Station Units 1 and 2, Docket Nos. 50-369 and 370; Catawba Nuclear Station Units 1 and 2, Docket Nos. 50-413 and 414; Response to NRC Request for Additional Information - TAC nos. MB3222, MB3223, MB3343 and MB3344) and License Amendment Request Supplement," August 7, 2002.

3. Letter from M. S. Tuckman, Duke Energy Corporation, to US Nuclear Regulatory Commission, "License Amendment Request Applicable to the Technical Specifications Requirements for the Core Operating Limits Report - Oconee, McGuire, and Catawba Technical Specifications 5.6.5," December 20, 2001.

4. Letter from Dennis Crutchfield, USNRC, to All Power Reactor Licensees and Applicants, "Removal of Cycle-Specific Parameter Limits from Technical Specifications (Generic Letter 88-16)," October 4, 1988.

5. DPC-NE-2009-P-A, "Duke Power Company Westinghouse Fuel Transition Report," December 1999.

6. Letter from J. S. Galembush, Westinghouse Electric Company, to US Nuclear Regulatory Commission, "1998 Annual Notification of Changes to the Westinghouse Small Break LOCA and Large Break LOCA ECCS Evaluation Models, Pursuant to 10 CFR 50.46(a)(3)(ii)," NSD-NRC-99-5839, July 15, 1999.

7. DPC-NF-2010A, "Duke Power Company McGuire Nuclear Station and Catawba Nuclear Station Nuclear Physics Methodology for Reload Design," June 1985.

8. DPC-NE-1004A, Revision 1, "Nuclear Design Methodology Using CASMO-3/ SIMULATE-3P," SER dated April 26, 1997.

9. DPC-NE-2011, "Nuclear Design Methodology Report for Core Operating Limits of Westinghouse Reactors," March 1990.

10. DPC-NE-1003, "Rod Swap Methodology Report for Startup Physics Testing," December 1986.

11. Letter from Darl Hood, USNRC, to H. B. Tucker, Duke Power Company, "Rod Swap Methodology Report for Startup Physics Testing, McGuire and Catawba Nuclear Stations, Units 1 and 2 (TACs 62981, 62982, 62983, 62984)," May 22, 1987.

12. Letter from Frank Rinaldi, USNRC, to H. B. Brown, McGuire Site, Duke Energy Corporation, "Issuance of Amendments - McGuire Nuclear Station, Units 1 and 2, (TAC Nos. M98964 and M98965)," September 30, 1998.

13. Letter from Peter Tam, USNRC, to G. R. Peterson, Catawba Nuclear Station, Duke Energy Corporation, "Issuance of Amendments - Catawba Nuclear Station, Units 1 and 2 (TAC Nos. M95298 and M95299)," September 30, 1998.

14. Letter from Frank Rinaldi, USNRC, to H. B. Brown, McGuire Site, Duke Energy Corporation, "McGuire Nuclear Station, Units 1 and 2, Re: Issuance of Amendments (TAC Nos. MA2411 and MA2412)," September 22, 1999.

15. Letter from Peter Tam, USNRC, to G. R. Peterson, Catawba Nuclear Station, Duke Energy Corporation, "Catawba Nuclear Station, Units 1 and 2, Re: Issuance of Amendments (TAC Nos. MA2359 and MA2361)," September 22, 1999.

16. Letter from Robert F. Martin, USNRC, to David L. Rehn, Catawba Site, Duke Power Company, "Issuance of Amendments - Catawba Nuclear Station, Units 1 and 2 Cycle Specific Parameters to the Core Operating Limits Report (TAC Nos. M85472 and M85473)," March 25, 1994.

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