REQUEST/APPROVAL PAGE

SAFETY RELATED PROCEDURE

Required Review Level (check one):
☐ **OSRC**
☒ **QUALIFIED REVIEW**

PROCEDURE NUMBER: NE-002-040	REVISION: 8	CHANGE: 0	DEVIATION: N/A

TITLE: CEA Group Worth Measurement

PROCEDURE OWNER (Position Title): Reactor Engineering

ACTIVITY (check one):
☐ Change ☒ Revision ☐ Deviation ☐ Deletion ☐ New Procedure ☐ Temporary Procedure

DESCRIPTION AND JUSTIFICATION:

Revised Tc in Section 7 to 541°F to comply with EPU Tc at low power.
Editorial changes were also made during this revision.

☐ Request/Approval Page Continuation Sheet(s) attached.

REVIEW PROCESS (check one):
☒ Normal ☐ Editorial Correction (May only be used with Changes, Revisions, and Deviations)

REVIEW AND APPROVAL ACTIONS		PRINT NAME OR SIGNATURE	DATE
PREPARER		Richard Baird	1/21/05
EC SUPERVISOR	Administrative Review and Approval	(sign) N/A	
CROSS-DISCIPLINE REVIEWS (List Groups)		N/A	
		N/A	
		N/A	
		N/A	
		N/A	
50.59 REVIEWER ☐ Programmatically Excluded: OSRC Mtg. No.:		V. McAdams	2/3/05
50.54 REVIEWER	Review ☐	N/A	
TECHNICAL REVIEWER	Review	V. McAdams	2/3/05
QUALIFIED REVIEWER	Review ☒	T. Goode	2-3-05
GROUP/DEPT. HEAD	Review ☐ Approval ☒	(sign) Clint L. Ashley	2-3-05
GM, PLANT OPERATIONS	Review ☐ Approval ☐	(sign) N/A	
VICE PRESIDENT, OPERATIONS	Approval ☐	(sign) N/A	

Effective Date / Milestone (if applicable): NRC approves license amendment request NPF-38-249 ~~and Extended Power Uprate is Implemented.~~ 4-18-05 TPG 4-11-05

Expiration Date / Milestone (if applicable):

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LIST OF EFFECTIVE PAGES

1-23 Revision 8

Reference Use

1.0 PURPOSE

To determine the worth of selected Control Element Assembly (CEA) Groups.

2.0 REFERENCES

2.1 NE-002-003, Post-refueling Startup Testing Controlling Document

2.2 NE-002-033, LPPT Base Power Level Determination

2.3 NE-002-050, Critical Boron Concentration Verification

2.4 NE-002-060, Isothermal Temperature Coefficient Measurement

2.5 OP-002-005, Chemical and Volume Control

2.6 Technical Specification Section 3/4.10, Special Test Exceptions

2.7 CEN-319, Control Rod Group Exchange Technique

3.0 DEFINITIONS

NONE

4.0 RESPONSIBILITIES

4.1 The Startup Test Coordinator (STC), assigned by the Reactor Engineering Superintendent, is responsible for the successful completion of this procedure.

4.2 Operations is responsible for plant manipulations to support this procedure.

5.0 PREREQUISITES

NOTE

While Special Test Exception 3.10.1 is invoked, record CEA positions every 2 hours by demanding a CEAC report or by completing Attachment 13.5 of NE-002-003. Either CEAC Channel may be used for position indication.

Initial/Date

5.1 Special Test Exception 3.10.1 has been invoked for the performance of this test. _____

NOTE

While Special Test Exception 3.10.2 is invoked, record reactor power hourly on Attachment 13.3 of NE-002-003, and maintain power within the limits determined in NE-002-033, LPPT Base Power Level Determination.

5.2 Special Test Exception 3.10.2 has been invoked for the performance of this test. _____

NOTE

While Special Test Exception 3.10.3 is invoked, record reactor power hourly in Attachment 13.4 of NE-002-003, and maintain reactor power $\leq$5%.

5.3 Special Test Exception 3.10.3 has been invoked for the performance of this test. _____

5.4 The designation of the CEA Groups and the sequence for the group swaps has been entered in Attachment 13.1 and is consistent with the Startup Test predictions used for NE-002-003. _____

6.0 PRECAUTIONS AND LIMITATIONS

6.1 All CEAs in a Shutdown Group, Regulating Group, or Group P should be kept within 1.5 inches of each other.

6.2 Volume Control Tank (VCT) make-ups should not be performed during the CEA exchange portion of this test. If possible, start this test with the VCT level at the high end of its operating band.

6.3 "Measurement Group" as used in this procedure refers to a group of CEAs which consists of one or more Regulating, Group P, or Shutdown Groups. The group swap portion of this test refers to the exchanging of two Measurement Groups with each other. Reactivity compensation is accomplished by movement of the Reference Group.

6.3.1 If a Measurement Group consists of more than one CEA group, alignment between those groups should be kept within approximately 15 inches during the exchange. However, final position of the CEA Groups should be within 1.5 inches of each other.

6.4 The reactivity computer strip chart should be annotated with the following information at least hourly and at each significant milestone during the test:

6.4.1 Date and time

6.4.2 Procedure step number

6.4.3 CEA group positions for any inserted groups

6.4.4 RCS temperature

6.4.5 RCS boron concentration

6.4.6 Reactivity computer chart speed and range

6.5 All borations and dilutions performed during this test will be done in accordance with OP-002-005, Chemical and Volume Control with the following exceptions:

6.5.1 Reactor Coolant System (RCS) dilution will be performed by direct injection through the Primary Makeup Water to Charging Pump Suction Header Isolation Valve (PMU-140) to the suction of the charging pumps.

6.5.2 At least two, but preferably three, charging pumps will be used during borations and dilutions.

6.6 Maximum pressurizer spray consistent with backup heater capacity should be used during borations and dilutions to equalize RCS boron concentrations.

6.7 All CEA group movements will be in the MANUAL GROUP mode unless otherwise specified.

7.0 INITIAL CONDITIONS

		Initial/Date
7.1	The reactor is critical with power being maintained at the base power specified in NE-002-003 for Low Power Physics Testing (LPPT) by CEA Group P movement.	_____
7.2	CEA Group P is greater than 130 inches withdrawn.	_____
7.3	All other CEAs are at their Upper Electrical Limit (UEL).	_____
7.4	RCS temperature is 541 ± 2.0 degrees F.	_____
	RCS Temperature = _____ °F	
7.5	Pressurizer (PZR) pressure is 2250 ± 50 psia.	_____
	PZR Pressure = _____ psia	

8.0 MATERIAL AND TEST EQUIPMENT

8.1 Westinghouse Advanced Digital Reactivity Computer (ADRC)

9.0 ACCEPTANCE CRITERIA

		Initial/Date
9.1	The measured worth of the Reference Group is within ±10% of the predicted worth.	_____
9.2	The measured worth of each CEA measurement group is within ± 0.10% Delta Rho ($\Delta\rho$) or ± 15% (whichever is larger) of the predicted CEA group worth.	_____
9.3	The measured total CEA group worth is within ±10% of the predicted total CEA group worth.	_____

10.0 PROCEDURE

10.1 REFERENCE GROUP WORTH

Initial/Date

10.1.1 Fully withdraw CEA Group P to the UEL. Compensate for the reactivity increase with insertion of the Reference Group. _____

10.1.2 Measure the Upper Residual Worth of the Reference Group as follows: _____

10.1.2.1 Withdraw the Reference Group to its Upper Group Stop (UGS). _____

10.1.2.2 Allow the reactivity trace to stabilize and annotate the reactivity computer chart per Step 6.4. _____

10.1.2.3 Adjust the Reference Group as necessary to maintain reactor power within the base power limits. _____

10.1.2.4 Adjust the Reference Group to bring reactivity as close as possible to zero and annotate the reactivity computer chart per Step 6.4. _____

10.1.2.5 At the discretion of the Startup Test Coordinator, Steps 10.1.2.1 through 10.1.2.4 may be performed two additional times. If additional measurements are NOT performed, then N/A this Step. _____

Initial/Date

10.1.3 Initiate an approximately 2 ppm/minute (±1 ppm/minute) boron dilution and adjust the reactivity computer chart speed so that the slope of the reactivity trace is about 45 degrees. _____

NOTE

The span of reactivity worth in Step 10.1.4 may be increased to ±50 pcm at the discretion of the Startup Test Coordinator.

Initial/Date

10.1.4 As reactivity reaches +30 pcm start insertion of the Reference Group. Insert the Reference Group smoothly until reactivity reaches approximately -30 pcm. _____

10.1.5 Continue diluting the Reference Group into the core, annotating the reactivity computer chart with Reference Group position each time insertion is stopped. _____

10.1.6 Stop the dilution when the Reference Group nears its Lower Group Stop as necessary to avoid overshoot. _____

10.1.7 Stabilize reactivity using the Reference Group and boration/dilution as necessary to result in a final Reference Group position of 0 to 15 inches withdrawn and annotate the reactivity computer chart per Step 6.4. _____

Initial/Date

10.1.8 Measure the Lower Residual Worth of the Reference Group as follows: _____

10.1.8.1 Insert the Reference Group to its Lower Group Stop (LGS). _____

10.1.8.2 Allow the reactivity trace to stabilize and record the Reference Group position on the reactivity chart. _____

10.1.8.3 Withdraw the Reference Group as necessary to bring reactor power within the base power limits. _____

10.1.8.4 Adjust the Reference Group to bring reactivity as close to possible to zero and record the Reference Group position on the reactivity computer chart. _____

10.1.8.5 At the discretion of the Startup Test Coordinator, Steps 10.1.8.1 through 10.8.1.4 may be performed two additional times. If additional measurements are NOT perfomed, then N/A this Step. _____

10.1.9 Complete Attachment 13.2 to determine the integral worth of the Reference Group and verify acceptance criteria compliance. An equivalent graph may be substituted for page 3 of 3. _____

10.2 MEASUREMENT GROUP WORTH

NOTE

NE-002-050, Critical Boron Concentration Verification and NE-002-060, Isothermal Temperature Coefficient Measurement may be performed at this time, if desired, and proceed with Step 10.2.1 upon completion of those tests.

		Initial/Date
10.2.1	Confirm the Pressurizer and VCT boron concentrations are within 20 ppm of the RCS boron concentration. Record below: RCS = _____ ppm VCT = _____ ppm PZR = _____ ppm	_____
10.2.2	Annotate the reactivity computer chart per Step 6.4.	_____
10.2.3	Ensure the CEAs of the first Measurement Group are aligned and then commence the exchange of the Reference Group with the first Measurement Group until the first Measurement Group is fully inserted.	_____
10.2.4	Position the Reference Group so as to bring reactivity as close to zero as possible. Stabilize reactivity and annotate the reactivity chart per Step 6.4.	_____
10.2.5	Ensure the CEAs of the next Measurement Group are aligned and then commence the exchange of the next Measurement Group with the present Measurement Group. Move the Reference Group as necessary to result in the next Measurement Group fully inserted and the present Measurement Group fully withdrawn.	_____
10.2.6	Stabilize reactivity using the Reference Group and annotate the reactivity chart per Step 6.4.	_____

		Initial/Date
10.2.7	Repeat Steps 10.2.5 and 10.2.6 until the worth of all Measurement Groups of Attachment 13.1 have been measured.	
10.2.8	Borate the last Measurement Group to the fully withdrawn position in accordance with OP-002-005, Chemical and Volume Control.	
10.2.9	Borate the Reference Group to greater than 135 inches withdrawn in accordance with OP-002-005, Chemical and Volume Control.	
10.2.10	Commence the exchange of Group P with the Reference Group until the Reference Group is fully withdrawn.	
10.2.11	Complete Attachment 13.3 to determine the worth of each CEA group and the total CEA worth and to verify acceptance criteria compliance.	
10.2.12	If applicable, return to NE-002-003.	

11.0 SETPOINTS

NONE

12.0 RECORDS

NONE

13.0 ATTACHMENTS

13.1 Designation and Sequence of CEA Groups to be Exchanged
13.2 Determination of Reference Group Integral Worth
13.3 CEA Exchange Worth Calculations

DESIGNATION AND SEQUENCE OF CEA GROUPS TO BE EXCHANGED

SEQUENCE	GROUPS(S) TO BE INSERTED*	GROUPS TO BE WITHDRAWN*
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

* Entries followed by the designation (R) are the Reference Groups.

Completed by: _____ Date _____

Reviewed by: _____ Date _____

DETERMINATION OF REFERENCE GROUP INTEGRAL WORTH

Initial/Date

13.2.1 Calculate the Upper Residual Worth of the Reference Group (Step 10.1.2) from the reactivity computer chart and record the result as the first entry of Table 13.2-1. _____

13.2.2 From the Reactivity Computer chart, determine the reactivity change and Group Integral Worth for each Reference Group Position during the insertion (Step 10.1.4). Record these values on Table 13.2-1. _____

13.2.3 Calculate the Lower Residual Worth of the Reference Group (Step 10.1.8) from the reactivity computer chart and record the result as the last entry of Table 13.2-1. _____

13.2.4 Plot the integral worth vs. group position on Figure 13.2-1 or equivalent. _____

13.2.5 Compare the Measured Reference Group Worth with the Predicted Reference Group Worth (used for NE-002-003) _____

Measured Worth = _____ pcm

Predicted Worth = _____ % $\Delta\rho$

(pcm = 1000 * % $\Delta\rho$)

Predicted Worth = _____ pcm

$$\%Difference = \frac{Measured - Predicted}{Predicted} * 100$$ (use pcm)

% Difference = _____

13.2.6 Confirm the Measured Worth is within ±10% of the Predicted Worth. _____

Performed By: _____ Date _____

Verified By: _____ Date _____

DETERMINATION OF REFERENCE GROUP INTEGRAL WORTH

Table 13.2-1

CEA Group # _____ Sheet __ of ____

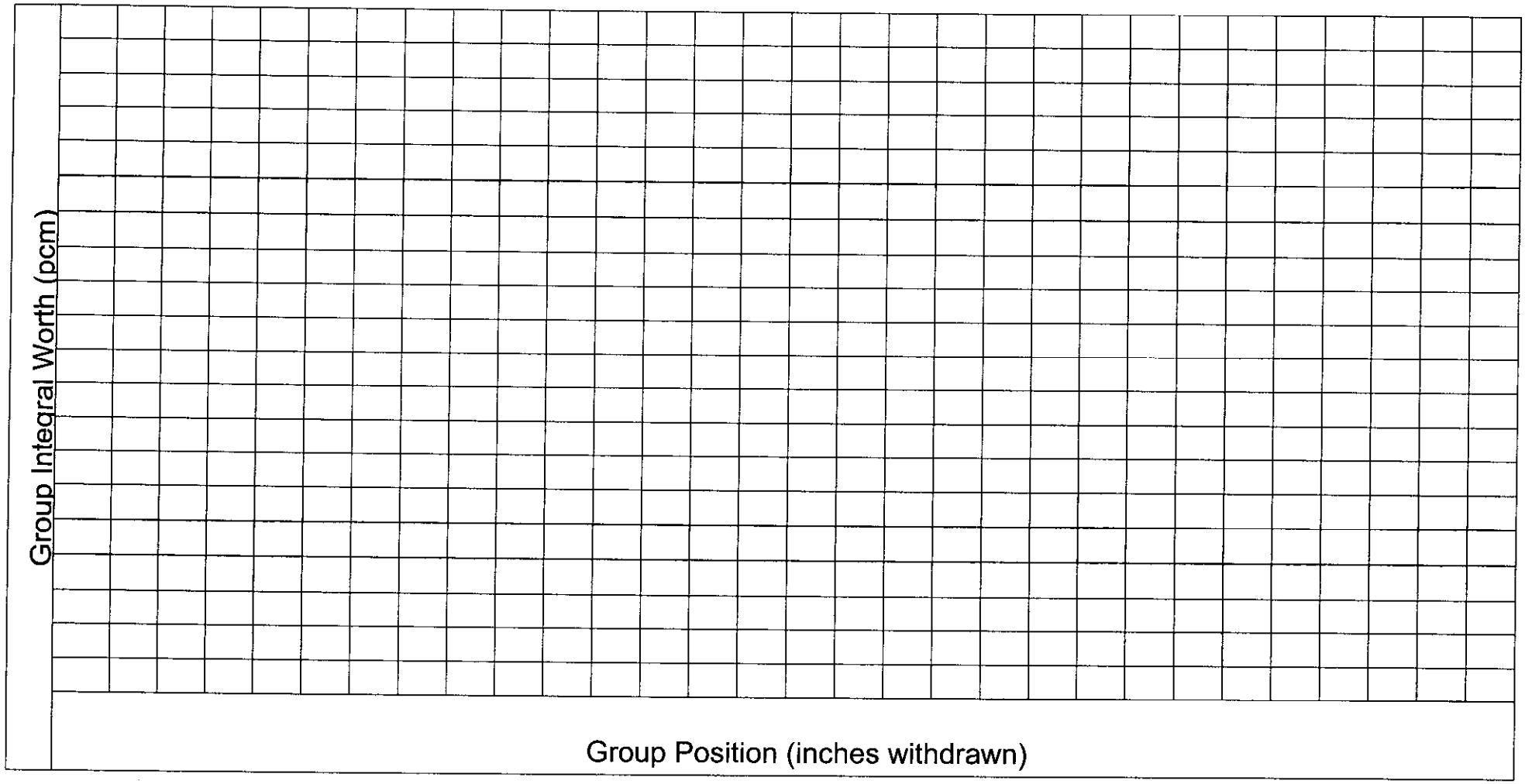
CEA GROUP POSITION (Inches W.D.)	GROUP POSITION CHANGE (inches)	REACTIVITY CHANGE (pcm)	GROUP INTEGRAL WORTH* (pcm)

* Summation of reactivity change column

Calculations Performed By: _____ Date: _____

Calculations Verified By: _____ Date: _____

DETERMINATION OF REFERENCE GROUP INTEGRAL WORTH
REFERENCE GROUP INTEGRAL
vs.
POSITION
FIGURE 13.2-1



CEA EXCHANGE WORTH CALCULATIONS

NOTE

The data and/or results determined in Steps 13.3.1 through 13.3.3 are to be recorded in Table 13.3-1. All reactivity units must be in pcm.

Initial/Date

13.3.1 Record the initial and final RCS average temperature (from the strip chart) for each exchange and calculate the delta. _____

13.3.2 Record the initial and final reactivity in pcm (from the strip chart) for each exchange and calculate the delta. _____

13.3.3 Record the initial and final boron concentrations for each exchange and calculate the average and the delta. _____

13.3.4 Record the Inverse Boron Worth. (Use measured value from NE-002-050 if it is available; if not, use predicted value).

IBW = _____ ppm/**pcm** _____

13.3.5 Record the Isothermal Temperature Coefficients measured in NE-002-060 and the corresponding boron concentrations, if available. Otherwise use the predicted values from Startup Test Predictions used for NE-002-003. _____

CEA CONFIGURATION	ITC (**pcm**/°F)	BORON CONCENTRATION (PPM)
EARO		
RODDED		

13.3.6 Using the data in Step 13.3.5 and linear interpolation, determine the ITC at the boron concentration (C_{Ba}) for each exchange and enter in Table 13.3-1. _____

CEA EXCHANGE WORTH CALCULATIONS

NOTE
Step numbers 13.3.7 through 13.3.14 correspond to column numbers in Table 13.3-2.

Initial/Date

13.3.7 Record the Measured Position (MP) of the Reference Group for each group inserted (determined in Steps 13.2.4). _____

13.3.8 Using the Measured Position from Table 13.3-2 and the measured integral reactivity worth curve for the Reference Group in Attachment 13.2, determine the Measured Worth (of the Reference Group) for each group inserted. _____

13.3.9 Using Attachment 13.2 and Figure 13.2-1 or equivalent, determine the residual worth of the Reference Group at its position at the start of the exchange (Step 10.2.2).

R_{RES} _____ pcm _____

13.3.10 Determine the Reactivity Correction (RC) for each group inserted using the following equation:

$$RC = R_{RES} + (ITC * \Delta T) - \frac{\Delta C_B}{IBW} + \Delta R$$ _____

where:
ITC = Isothermal Temperature Coefficient from Step 13.3.6, pcm/°F
ΔT = Change in RCS Temperature from Step 13.3.1, °F
ΔC_B = Change in boron concentration from Step 13.3.3, ppm
IBW = Inverse Boron Worth from Step 13.3.4, pcm
ΔR = Change in reactivity from Step 13.3.2, pcm
R_{RES} = Residual worth of Reference Group from Step 13.3.9, pcm

CEA EXCHANGE WORTH CALCULATIONS

Initial/Date

13.3.11 Determine the Adjusted Worth for each group inserted by subtracting the Reactivity Correction from the Measured Worth:

Adjusted Worth = Measured Worth (Step 13.3.8) - Reactivity Correction (Step 13.3.10)

Adjusted Worth = _____ - _____

Adjusted Worth = _____ pcm _____

13.3.12 Record the Predicted Worth of the Measurement Groups and the Reference Group in Table 13.3-2. These predictions are in the Startup testing predictions used for NE-002-003. _____

13.3.13 Determine the difference between the measured and predicted reactivity worths.

Difference = (Step 13.3.11) - (Step 13.3.10)

Difference = _____ - _____

Difference = _____ pcm _____

13.3.14 Confirm that the CEA Worth Acceptance criteria have been met. _____

CEA EXCHANGE WORTH CALCULATIONS
Table 13.3-1
CEA EXCHANGE DATA SHEET

Groups Inserted	Temperature (deg F) (Step 13.3.1)			Reactivity (pcm) (Step 13.3.2)			Boron Concentration (ppm) (Step 13.3.3)				ITC
	Initial T_i	Final T_f	Delta T	Initial ρ_i	Final ρ_f	Delta ρ	Initial C_{Bi}	Final C_{Bf}	Average C_{Ba}	Delta C_B	

Delta = Final - Initial

Calculations Performed By: _____ Date: _____

Calculations Verified By: _____ Date: _____

CEA EXCHANGE WORTH CALCULATIONS
TABLE 13.3-2
CEA EXCHANGE FINAL RESULTS

Group(s) Inserted	(Step 13.3.7) Measured Position (in. wd.)	(Step 13.3.8) Measured Worth (pcm)	(Step 13.3.10) Reactivity Correction (pcm)	(Step 13.3.11) Adjusted Worth (pcm)	(Step 13.3.12) Predicted Worth (pcm)	(Step 13.3.13) Measured Error % or abs*	(Step 13.3.14) Criteria Satisfied (Yes/No)
			Total				

$$\%Difference = \frac{Measured - Predicted}{Predicted} * 100$$

* Absolute Error = Measured - Predicted

Calculations Performed By: _____ Date: _____

Calculations Verified By: _____ Date: _____