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Dr. Thomas E. Murley, Director  
Office of Nuclear Reactor Regulation  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

Attn: NRC Document Control Desk

Subject: Braidwood Unit 2  
Initial Use of Rod Worth Measurement  
Using the Rod Exchange Technique  
NRC Docket No. 50-457

Reference (a): NUREG-1002, Safety Evaluation  
Report Supplement 2, dated October, 1986

Section 4.3.2 of Reference (a) provided the NRC evaluation which allowed Braidwood Station to use the Rod Exchange method to measure the worth of Rod Control Cluster Banks. Condition (4) of Section 4.3.2 of reference (a) requires that "...a report comparing the measured and predicted rod worths will be submitted to the NRC within 45 days of the completion of the rod worth tests for the first use of rod swap of a reload at each unit." The purpose of this letter is to respond to this requirement.

Attachment A provides a brief description of the calculations performed in accordance with the Braidwood Station procedure used to make the rod worth measurements. Table 1 of attachment A summarizes the results obtained.

This information is being provided for NRC review. Please address any questions regarding this submittal to this office.

Very truly yours,

*S. C. Hunsader*  
S.C. Hunsader

Nuclear Licensing Administrator

cc: S.P. Sands-NRR  
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BWD Resident Inspector

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# ATTACHMENT A

## Braidwood Unit 2, Cycle 2

### Zero Power Physics Testing

#### Rod Worth Measurement Results

The purpose of this test was to determine the differential and integral worth of the reference bank over its entire travel in an unroddeed core and to determine the integral worths of the remaining banks using the rod exchange method. Adequate shutdown margin exists based on the rod worth measurements meeting the required acceptance criteria.

The rod exchange technique required calculations by Nuclear Fuel Services (Reference 2) providing estimated critical positions of the reference bank after exchange with the bank being measured.

$h_x^P$ , and the associated correction factors,  $\alpha_x$ . The measurements were obtained for three reference bank positions:

- a) Initially fully inserted position,  $(h_x^M)_{Initial}$
- b) Critical position after exchange,  $h_x^M$
- c) Final fully inserted position,  $(h_x^M)_{Return}$

The worth of a measured bank,  $w_x^I$ , is:

$$w_x^I = w_R^M - (\Delta\rho_1)_x - \alpha_x(\Delta\rho_2)_x$$

where:

- 1)  $w_R^M$  = The total measured worth of the reference bank.
- 2)  $(\Delta\rho_2)_x$  = The reference bank worth from 0 steps to the average of  $(h_x^M)_{Initial}$  and  $(h_x^M)_{Return}$
- 3)  $(\Delta\rho_2)_x$  = The reference bank worth from  $h_x^M$  to 228 steps.

- 4)  $\alpha_x$  = A correction factor for the  $h_x^M$  worth due to the  
rodded geometry.

Rod worth measurements were performed under the guidance of Westinghouse Rod Exchange topical (Reference 3). The document states that the allowable percent difference between measured and predicted reference bank worth is 10%, 15% for individual rod banks and 10% for the sum of all measured rod banks. For individual banks with a predicted worth less than 667 pcm the allowable difference is 100 pcm rather than 15%.

The worth of reference bank (CBC) was measured by dilution. The percent difference between the predicted worth and the measured worth by dilution of CBC was determined to be -3.2%, which is well within the allowable limits as stated above. The results of the rod worth measurements based on the dilution measurement of CBC are shown in Table 1.

Using the rod exchange technique, all control and shutdown banks were exchanged with CBC. The largest percent difference between a measured and predicted rod worth was -10.4% for Control Bank A. Since the predicted worth of CBA was 446 pcm (< 667 pcm) the allowable difference was 100 pcm. The largest difference between a measured and predicted rod worth in pcm was -55.6 pcm for Shutdown Bank E. This value is below the allowable difference of 100 pcm. The measured total worth of all banks, based on dilution measurements of CBC, was 5012.3 pcm which differs by -1.6% from the predicted worth. All safety and design acceptance criteria were met.



## ATTACHMENT A TABLE 1

## ROD EXCHANGE MEASUREMENTS

## DILUTION

## BRAIDWOOD UNIT 2, CYCLE 2

Reference Bank BANK Inserted $(h_x)_0^M$ (steps)					Reference Bank Withdrawn $M$ $h_x$ (steps)	$\alpha_x$	$(\Delta\rho_1)_x$ (pcm)	$(\Delta\rho_2)_x$ (pcm)	$\alpha_x(\Delta\rho_2)_x$ (pcm)	Inferred Worth $I$ $W_x$ (pcm)	Predicted Worth $P$ $W_x$ (pcm)	Percent Difference (%)	
No.	ID	Initial	Return	Average									
1	C	--	--	--	--	--	--	--	--	901.6	931	-3.2	
2	D	22	22	22	146	1.08	14.3	355.7	384.2	503.1	503	0.0	
3	B	22	22	22	196.5	1.28	14.3	160.2	205.1	582.2	669	2.0	
4	A	22	22	22	95	0.91	14.3	535.9	487.7	399.6	446	-10.4	
5	SD	22	22	22	130.5	1.09	14.3	404.1	440.5	446.8	428	4.4	
6	SC	22	22	22	130	1.09	14.3	405.8	442.3	445.0	428	4.0	
7	SB	22	22	22	208	1.01	14.3	82.2	83.0	804.3	830	-3.1	
8	SA	22	22	22	99	1.10	14.3	519.1	571.0	316.3	289	9.4	
9	SE	22	23	22.5	130	0.92	14.9	405.8	373.3	513.4	569	-9.8	
Measured Integral Reference Bank Worth, $W_R^M = 901.6$ (pcm)										Total	5012.7	5093.0	-1.6
Calculations: $M^1$ $M^M$ $(\Delta\rho_1)_x$ $(\Delta\rho_2)_x$													

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

Percent Difference =  $(W_x^I - W_x^P) / W_x^P \times 100$

Note: Predicted values from Reference 2.