Babcock & Wilcox

a McDermott company

Research & Development Division
Lynchburg Research Center

P.O. Box 1260
Lynchburg, Virginia 24505
(804) 384-5111

July 9, 1981

Mr. James R. Miller, Chief
Standardization and Special
Projects Branch
Division of Licensing
N. R. R.
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Reference: License CX-10, docket 50-13

Dear Mr. Miller:

Amendment Number 11 to the referenced license, paragraph 2.B requires that a report be submitted at the conclusion program authorized by the amendment. In compliance with paragraph 2.B I have attached the required report.

If you have any questions in this regard, please contact me.

Very truly yours,

Arne F. Olsen

Arne F. Olsen
Senior License Administrator

AFO:ccf

Attachment

A020
S1/1

1.0 SUMMARY

The critical experiment program authorized by Amendment 11 to the CX-10 Operating License is complete. Experimental measurements verified that all core parameters were within prescribed license limits. In addition, experimental measurements were made correlating reactivity worth with water height. This correlation indicates that the estimate of reactivity addition rate that would result from pumping unborated water into the core tank as described in the application was conservative.

2.0 BACKGROUND

B&W's request for Amendment 11 to the CX-10 Operating License (Docket #50-13) was sent to the USNRC by reference a. The experimental program for which Amendment #11 was sought required the construction of critical arrays using densely packed lattices of low-enriched UO_2 fuel pins. Each array was to be built from one of three types of tightly packed fuel pin bundles. The details of the proposed configurations are discussed in reference a.

The Hazards Evaluation Report for the proposed program (reference a) was supplemented by references b, c, and d. Amendment #11 was issued by the USNRC and forwarded to B&W by reference e. Reference e required that B&W "submit a written report to the commission following completion of the program that describes and compares the measured results of various criticality experiments with the calculated and extrapolated values described in the application." The exeriments were completed in March of 1981, and the preliminary analysis of experimental results was finished in July. This document comprises the written report required by paragraph 2.B of Amendment #11.

3.0 DISCUSSION

3.1 DESCRIPTION OF EXPERIMENTS

The proposed experimental program (including facility modifications, core configurations, type of fuel, and scope of experiments) was described in reference a. The experiments were performed essentially as described therein.

3.2 MEASUREMENTS

To provide a useful body of benchmark data and to ensure that limits imposed by the CX-10 License and Operating Procedures were being met, the following measurements were made:

- Rod worth
- Rod withdrawal rate and drop times
- Moderator fill rate
- Ambient radiation levels during reactor operation
- Moderator temperature
- Power level
- Critical Water Height
- Fuel spacing and geometry
- Moderator boron concentration
- $\Delta\rho/\Delta H$ (discussed below)

A correlation between reactivity and moderator height was developed for cores using each of the three module types. From a licensing standpoint, this kind of correlation is important for three reasons:

1. The license restricts maximum excess reactivity by moderator fill (i.e., the difference in reactivity between a given critical configuration and the same core at full moderator height) to 2% $\Delta K/K$. Ensuring that this restriction is met requires knowledge of differential water height worth as a function of water level.

2. Maximum reactivity addition rate by moderator fill is restricted to less than or equal to .05% $\Delta K/K$/sec when $K_{eff} \leq 0.98$. Ensuring that this limit is met requires the same information as item 1 above.

3. The analysis of the maximum credible accident (MCA) discussed in reference a is based on a correlation between reactivity and water height obtained from previous core loadings. Measurements on the as-built cores would help corroborate that analysis.

$\Delta\rho/\Delta H$ data were therefore taken to ensure that certain license limits were met and to support the hazards evaluation discussed in the application. Basically, these measurements consisted of determining the reactivity worth of incremental changes in water height at various water levels. These data were taken as follows:

1. The moderator level was slowly increased until the reactor was slightly supercritical.
2. The stable reactor period was measured by timing the rise in neutron flux level through several decades. The water level at the supercritical condition was recorded.
3. The moderator level was dropped until the reactor was just critical. The decrement in water level between the supercritical and critical conditions was calculated and recorded. This is the "ΔH" referred to in the term "$\Delta\rho/\Delta H$".
4. The reactor period was converted to reactivity units using the in-hour equation. This is the "$\Delta\rho$" referred to in the term "$\Delta\rho/\Delta H$".

After each set of $\Delta\rho/\Delta H$ vs H had been collected, it was correlated and used to calculate $d\rho/dt$ (reactivity addition rate) during the postulated unborated water addition accident as outlined in Appendix A-1 of the application. In analyzing and extrapolating the $\Delta\rho/\Delta H$ data to determine $d\rho/dt$, we conservatively accounted for uncertainties in important parameters and the "scatter" of experimental data. The results of the analysis are presented in Table 1.

Table 1 indicates that the estimates of $d\rho/dt$ during the moderator fill accident on which the MCA was based are conservative. All other measured core parameters were found to be within the limits prescribed by the CX-10 Operating License.

TABLE 1.

Comparison between Pre-Experiment and Post-Experiment Estimates of Maximum Reactivity Addition Rates by Moderator Fill (Accident Condition)

Loading	Conservatively Estimated $d\rho/dt$ @ Minimum Critical Water Height as Reported in Application	Conservatively Estimated $d\rho/dt$ @ Minimum Critical Water Height Based on Experimental Measurement of As-Built Cores
Loose-Packed Square Pitch Modules (0.7" spacing)	.047%/sec*	.042%/sec
Tight-Packed Square Pitch Modules (0.7" Spacing)	.0275%/sec	.022%/sec
Triangular Pitched Module (0.7" spacing)	.0162%/sec	.0144%/sec

* To more conservatively account for various uncertainties in the analysis, this estimate was upped to .056%/sec in reference d.

REFERENCES

a. Letter to USNRC (Robert W. Reid, Chief, Operating Reactors Branch #4) from Babcock & Wilcox Co. (A. F. Olsen) dated October 18, 1979. (Docket No. 50-13)

b. Letter to USNRC (Robert W. Reid, Chief, Operating Reactors Branch #4) from Babcock & Wilcox Co. (A. F. Olsen) dated January 16, 1979. (Docket No. 50-13)

c. Letter to USNRC (Robert W. Reid, Chief, Operating Reactors Branch #4) from Babcock Wilcox Co. (A. F. Olsen) dated April 11, 1980. (Docket No. 50-13)

d. Letter to USNRC (Robert W. Reid, Chief, Operating Reactors Branch #4) from Babcock & Wilcox Co. (A. F. Olsen) dated April 30, 1980 (Docket No. 50-13)

e. Letter to Babcock & Wilcox Co. (A. F. Olsen) from USNRC (James R. Miller, Chief, Standardization and Special Projects Branch) dated May 30, 1980 (Docket No. 50-13)