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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO THE REPORT, "CONTROL BANK REACTIVITY WORTH DETERMINATION

USING THE ROD SWAP TECHNIQUE"

UNION ELECTRIC COMPANY

CALLAWAY NUCLEAR PLANT

DOCKET NO. 50-483

1.0 INTRODUCTION

By letter dated June 28, 1991 (Ref. 1), the Union Electric Company (UE) submitted a report entitled, "Control Bank Reactivity Worth Determination Using the Rod Swap Technique." The report describes UE's methodology and techniques for determining control and shutdown bank reactivity using the rod swap method. It also includes benchmark data to support the proposed methods as well as the review and acceptance criteria to be used. Additional information was submitted by letter dated September 12, 1991 (Ref. 2).

The report contains comparisons of calculated and measured data for Callaway Cycles 4 and 5. The September 12, 1991 submittal included additional rod swap benchmarks and comparisons of UE and vendor dilution-mode bank worth predictions.

Control and shutdown bank reactivity worth testing is part of the normal reload physics testing sequence at nuclear power plants. The main purpose of the bank worth testing is to validate the cycle-specific core models used to design the reload, especially in terms of shutdown margin. Although, the measurement conditions are not those used in the accident analysis, 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.

The traditional method of rod worth measurement is boron dilution. Starting from an all-rods-out configuration, the bank is inserted a few steps at a time and the reactor is kept critical by diluting the boron concentration. The first control bank is inserted until it is all the way in and then the next bank is 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 The worth of the bank is also equal to the difference in boron concentrations from the bank fully withdrawn to fully inserted positions. Usually about half of the banks are measured when using this method.

An alternative method of rod worth measurement is called "rod swap" or "rod exchange." In this method the highest worth bank, called the reference bank, is measured by boron dilution and the 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.

2.0 EVALUATION

The methodology proposed by UE is equivalent to methods previously approved for other utilities (Refs. 3 and 4). Although certain calculational sequences and data manipulations may differ, the methods are fundamentally the same, in terms of the number of measurements taken, the conservatism of the acceptance/review criteria, and the fact that calculations represent what is actually being measured in the core.

Rod swap measurements were taken at Callaway during Cycles 4 and 5 startups. All nine banks were measured for Cycle 5, while only six banks were measured for Cycle 4. Comparisons are made between measured and predicted rod worths for both the dilution and rod swap measurements. Also comparisons are made between UE and the vendor predictions.

The percent deviations between measured and predicted for rod swap are compared to those of boron dilution. The standard deviation of boron dilution measurements versus predictions is 3.96%, while the standard deviation of the rod swap measurements is 2.44%. For the Cycle 4 measurements the boron dilution worth deviations for individual banks ranged from 3.4% to 5.6%, and the deviation of the sum of all banks was 4.2%. Corresponding numbers for rod swap were -3.8% to 6.1% for individual banks and 0.2% for the sum of the banks. In Cycle 5, the boron dilution worth range was -1.3% to 5.4% with a 2.2% deviation on the total sum. The rod swap range was 0.1% to 4.2% with a 1.8% deviation on the total sum.

Comparison of the vendor predicted worths with those by UE resulted in differences from -2.5% to 4.6% for Cycle 4 and -7.9% to 9.0% for Cycle 5. Additional rod swap benchmarks for another plant resulted in measurement-to-prediction deviations of -10.4% to 0.0% for individual banks and -4.1% for the sum of the banks.

The rod swap benchmark data demonstrates that the Union Electric Company's methodology is highly accurate in performing calculations necessary for the rod swap technique. These comparisons confirm that UE's rod swap methodology is equivalent to boron dilution in terms of validation of design models.

Although direct comparison of rod swap measurements against design calculations is the primary validation technique, other types of comparisons using the same methodologies provide additional validation All physics measurements are generally impacted by the same set of core parameters (i.e. power distribution,

boron concentration, cross sections, etc.). UE has provided additional benchmarking comparisons. These comparisons include Hot Zero Power (HZP) boron endpoints, HZP reactivity coefficients, HZP boron letdown, and in-core detector reaction rates for Beginning of Cycle (BOC), Middle of Cycle (MOC), and End of Cycle (EOC) burnup points. In addition comparisons of UE and vendor boron dilution bank worth predictions were provided. All of these comparisons showed results within acceptance criteria. In almost all cases the agreement was excellent, nearly always within 5%. This further confirms Union Electric's ability to perform the calculations necessary for rod swap.

Union Electric's proposed review and acceptance criteria structure is fundamentally the same as that approved by other utilities. Since a vendor will continue to perform the licensed reload design and safety evaluations for Callaway, the criteria on individual bank worths and the total worth of all the banks will be tightened as described in Section 4.2 of the report.

3.0 CONCLUSIONS

The Union Electric Company rod swap methodology is essentially the same as those approved for other utilities. Rod swap benchmark data comparing predictions and measurements show excellent agreement. Additional physics parameter comparisons further add to the validity of the methodology. The acceptance and review criteria as proposed by the licensee are acceptable. Based on the above, the staff finds the rod swap methodology as presented in the report and the additional information acceptable for use by Union Electric Company for the Callaway Plant. As is always the case with approval of the use of rod swap, all banks, both control and shutdown, must be measured each cycle whenever rod swap is used.

4.0 REFERENCES

1. Letter from Donald F. Schnell, Union Electric Company, to Nuclear Regulatory Commission, dated June 28, 1991.

2. Letter from Donald F. Schnell, Union Electric Company, to Nuclear Regulatory Commission, dated September 12, 1991.

3. VEP-FRD-36A, "Control Rod Reactivity Worth Determination By The Rod Swap Technique," Virginia Electric & Power Co., December 1990.

4. NFG-004, Safety Evaluation of The PSE&G Rod Exchange Methodology," Rev. 2, Public Service Electric & Gas Co., August 22, 1984.

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