U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

BRANCH TECHNICAL POSITION 4-1

WESTINGHOUSE CONSTANT AXIAL OFFSET CONTROL (CAOC)

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of the assessment of reactor physics, neutronics, and nuclear design

Secondary - None

A. BACKGROUND

In connection with the staff review of WCAP-8185 (17 × 17), the staff reviewed and accepted a scheme developed by Westinghouse for operating reactors that assures that throughout the core cycle, including during the most limiting power maneuvers the total peaking factor, F_Q, will not exceed the value consistent with the LOCA or other limiting accident analysis. This operating scheme, called constant axial offset control (CAOC), involves maintaining the axial flux difference within a narrow tolerance band around a burnup-dependent target in an attempt to minimize the variation of the axial distribution of xenon during plant maneuvers.

Originally (early 1974), the maximum allowable F_Q (for LOCA) was 2.5 or greater. Later (late 1974), when needed changes were made to the emergency core cooling system (ECCS) evaluation model, Westinghouse, in order to meet physics analysis commitments to all its customers at virtually the same time, did a generic analysis (one designed to suit a spectrum of

operating and soon-to-be-operating reactors) and showed that most plants could meet the requirements of 10 CFR 50 Appendix K and 10 CFR 50.46 (i.e., 1204°C (2200°F)) peak clad temperature) if the value for F_Q were less than 2.32. Westinghouse also showed that CAOC procedures employing a ± 5-percent target band would limit peak F_Q for each of these reactors to less than 2.32.

The staff recognized at that time, however, that not all plants needed to maintain F_Q below 2.32 to meet fuel acceptance criteria (FAC) or needed to operate within a ± 5-percent band to achieve a value for F_Q less than 2.32. In fact, Point Beach was allowed to operate within a wider band because the Wisconsin Electric Power Company demonstrated to the NRC's satisfaction that the reactors could be maneuvered within a wider band (+6, -9 percent) and still hold F_Q below 2.32. The staff fully expected that in time most plants would have individual CAOC analyses and procedures tailored to the requirements of their plant-specific ECCS analyses.

Therefore, when the staff accepted CAOC, it was not just F_Q value equal to 2.32 and a ± 5-percent bandwidth the staff were approving, but the CAOC methodology. This is analogous to the staff's review and approval of ECCS and fuel performance evaluation models.

The CAOC methodology, which is described in WCAP-8385 and WCAP-8403, entails (1) establishing an envelope of allowed power shapes and power densities, (2) devising an operating strategy for the cycle which maximizes plant flexibility (maneuvering) and minimizes axial power shape changes, (3) demonstrating that this strategy will not result in core conditions that violate the envelope of permissible core power characteristics, and (4) demonstrating that this power distribution control scheme can be effectively supervised with ex-core detectors.

Westinghouse argues that point 3, in the CAOC methodology above (i.e., demonstrating the core conditions will not violate the envelope of permissible core power characteristics) is achieved by calculating all of the load-follow maneuvers planned for the proposed cycle and showing that the maximum power densities expected are within limits. These calculations are performed with a radial/axial synthesis method that has been shown to predict conservative power densities when compared to experimental data. While the staff has accepted CAOC on the basis of these analyses, it also requires that power distributions be measured throughout a number of representative (frequently limiting) maneuvers early in cycle life to confirm that peaking factors are no greater than predicted.

Additionally, the staff is sponsoring a series of calculations at Brookhaven National Laboratory to check aspects of the Westinghouse analysis.

The power distribution measurement tests described above will, of course, automatically relate in-core and ex-core detector responses and thereby validate that power distribution control can be managed with ex-core detectors.

B. BRANCH TECHNICAL POSITION

An applicant or licensee proposing CAOC for other than an F_Q value equal to 2.32 and a bandwidth equal to ± 5 percent is expected to provide the following:

1. Analyses of F_Q × power fraction showing the maximum $F_Q(z)$ at power levels up to

100 percent and departure from nucleate boiling performance with allowed axial shapes relative to the design bases for overpower and loss of flow transients. The envelope of these analyses must be shown to be valid for all normal operating modes and anticipated reactor conditions. (See Table 1 of the letter from Westinghouse Electric Corporation to U.S. Nuclear Regulatory Commission, July 16, 1975, for the cases that must be analyzed to form such an envelope.)

2. A description of the codes used, how cross-sections for cycle were determined, and what F_{xy} values were used.

3. A commitment to perform load-follow tests wherein F_Q is determined by taking in-core maps during the transient. (Note: Westinghouse has outlined for both the NRC staff and the Advisory Committee on Reactor Safeguards (ACRS) an augmented startup test program designed to confirm experimentally the predicted power shapes. This program is presented in the Westinghouse Electric Corporation publication on, "Augmented Startup and Cycle 1 Physics Program," WCAP-8575, August 1975 describes this program. The tests will be carried out at several representative - both 15 × 15 and 17 × 17 - reactors. The staff has endorsed these tests as has the ACRS in its June 12, 1975, letter for the Diablo Canyon plant. In addition, for the near term, the staff plans to require that those licensees who propose to depart from the previously approved peaking factor and target bandwidth perform similar tests (the precise ones will be determined on a case-by-case basis) to broaden the confidence in analytical methods by extending the comparison of prediction with measurement to include more and more burnup histories.

C. REFERENCES

1. T. Morita, et al., "Power Distribution Control and Load Following Procedures," WCAP-8385 (proprietary) and WCAP-8403 (nonproprietary), Westinghouse Electric Corporation, September 1974.

2. C. Eicheldinger, Westinghouse Electric Corporation, Letter to D.B. Vassallo, U.S. Nuclear Regulatory Commission, July 16, 1975.

3. K.A. Jones, et al., "Augmented Startup and Cycle 1 Physics Program," WCAP-8575, Westinghouse Electric Corporation, August 1975.