



## 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

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This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to [NRR\\_SRP@nrc.gov](mailto:NRR_SRP@nrc.gov).

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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  $\pm 5$ -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  $\pm 5$ -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  $\pm 5$ -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  $\pm 5$  percent is expected to provide the following:

1. Analyses of  $F_Q \times$  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 x 15 and 17 x 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.

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#### **PAPERWORK REDUCTION ACT STATEMENT**

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

#### **PUBLIC PROTECTION NOTIFICATION**

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