2.10.3 In-Core Instrumentation

Applicability

Applies to the operability and alarm values of the rhodium detector in-core instruments system.

Objective

To specify the functional requirements on the use of the rhodium in-core instrumentation system for (1) the recalibration of the ex-core detector inputs to the axial power distribution trip calculators and (2) monitoring of kw/ft and power distribution.

Specification

(1) A minimum of four in-core locations at each detector level (or a total of 16 detectors) with at least one location in the center seven rows of fuel assemblies and at least one location outside the center seven rows of fuel assemblies shall be operable during recalibration of the ex-core detectors.

(2) The in-core detector system shall be operable (an operable in-core detector string consists of three or more operable rhodium detectors) with either:

(a) A normal complement consisting of:

1. At least 75% of all in-core detector strings operable, and

2. A minimum of two operable in-core detector strings per full axial length quadrant

whenever the in-core system is used to monitor F_{xy}^T, F_R^T, the radial power distribution and the peak linear heat rate, or

(b) A reduced complement consisting of:

1. At least 20% of all in-core detector strings operable, and

2. A minimum of one operable in-core detector string per full axial length quadrant

whenever the in-core detector system is used to monitor F_{xy}^T, F_R^T, the peak linear heat rate, and the radial power distribution, provided:

(i) The planar radial peaking factor uncertainty, U_{xy}, the integrated radial peaking factor uncertainty, U_R, and the total peaking factor uncertainty, U_q, are determined every 31 EFPD, in accordance with a cycle specific analysis performed in a manner as given in the reference.

(ii) If $U_R > .06$ the value of F_R to be used in evaluating the approach to the limits of Specification 2.10.4(2) is:

$$F_R = F_R^M (1 + U_R - 0.06)$$

where F_R^M is determined from a power distribution map with no part length CEA's inserted and all full length CEA's at or above the Long Term Steady State Insertion limit for the existing Reactor Coolant Pump combination, and the integrated radial peaking factor uncertainty, U_R, is the latest determined value of U_R at the time F_R^M is determined.

(iii) If $U_{xy} > .07$ the calculated value of F_{xy} to be used in evaluating the approach to the limits of Specification 2.10.4(3) is:

$$F_{xy} = F_{xy}^M (1 + U_{xy} - 0.07)$$

where F_{xy}^M is determined from a power distribution map with no part length CEA's inserted and all full length CEA's at or above the Long Term Steady State Insertion limit for the existing Reactor Coolant Pump combination and the planar radial peaking factor uncertainty, U_{xy}, is the latest determined value of U_{xy} at the time F_{xy}^M is determined.

(iv) If $U_q > .07$ the total peaking factor uncertainty factor defined as $(1 + U_q)$ shall be used in place of the measurement-calculation factor of 1.07 in Specification 2.10.4(1).

(v) The maximum local peak linear heat rate in the core, Φmax, shall be determined and the incore detector alarms shall be adjusted to no greater than the following:

$$\text{Alarm Setting} = \frac{C * \Phi\text{allowed}}{\Phi\text{max}}$$

where:

C = The detector signal converted to flux units when the reactor is operating at steady-state.

Φallowed = Linear heat rate (kw/ft) allowed by Specification 2.10.4(1) and adjusted as required by Specification 2.10.3(2)(b)(iv).

Φmax = The maximum local peak linear heat rate (kw/ft) measured at the same reactor conditions as C above.

(3) If the in-core detector system is not operable within the interval specified, the peak linear heat rate shall be monitored by ex-core detectors per Specification 2.10.4(1)(c) and the surveillance requirements of Specification 3.10(5) are deleted.

(4) If the recalibration of the ex-core detectors has not been accomplished within the previous 30 equivalent full power days, reduce the axial power distribution monitoring limits and trip setpoints, Figures 2-6, 2-7, and 1-2, by 0.03 ASI units. If the recalibration of the ex-core detectors has not been accomplished within the previous 200 equivalent full power days, the power shall be limited to less than that corresponding to 75% of the peak linear heat rate permitted by Specification 2.10.4.(1).

(5) After each fuel loading, the incore detector system shall be operable with at least 75% of the incore detector strings operable and a minimum of two quadrant symmetric incore detector string locations per core quadrant for the initial measurement of the linear heat rate, F_R^T, F_{xy}^T and the azimuthal power tilt.

(a) An operable incore detector string shall consist of three operable rhodium detectors.

(b) A quadrant symmetric incore detector string location shall consist of a location with a symmetric counterpart in any other quadrant.

(c) The initial measurement of the linear heat rate, F_R^T, F_{xy}^T and azimuthal power tilt shall consist of the first full core power distribution calculation based on incore detector signals made at a power level greater than 40 percent of rated power following each fuel loading.

If an initial measurement of the linear heat rate, F_R^T, F_{xy}^T and azimuthal power tilt cannot be made with an operable incore detector system as defined above, reactor power shall be restricted to less than 75 percent of the peak allowable heat rate.

Basis

The in-core instrument system is used to monitor core performance and to insure operation within the limits used as initial conditions for the safety analysis in three ways:

(1) to verify that the radial peaking factors (F_{xy}^T and F_R^T) are less than the limits specified in Specifications 2.10.4(2) and 2.10.4(3),

(2) to actuate alarms set on each individual instrument to insure operation within specified kw/ft limits of Figure 2-5, and

(3) to determine the axial shape index for periodic verification of the calibration of the ex-core detector system.

The specification requires a minimum number of detectors and proper distribution to perform these functions. In-core rhodium detectors in conjunction with analytical computer codes calculate power distributions from which F_{xy} and F_R are determined. Alarm limits are set on each in-core instrument to insure operation within specified kw/ft limits.

Operation of the in-core detector system for peak linear heat rate monitoring and surveillance of F_R^T and F_{xy}^T with less than 75% of the strings operable requires additional measures to compensate for degradation of the in-core instrument system. Periodic comparisons between calculated and measured power distributions are made to confirm the core is depleting as designed. The measurement uncertainties are computed to assure the assumptions made in the setpoint analysis are valid. The uncertainties are computed using the methods given in the reference.

If the determined uncertainties exceed the uncertainties used in the setpoint and safety analysis, the measured values of F_R and F_{xy} are augmented by the appropriate uncertainty. These new values of F_R and F_{xy} are then used to verify compliance with Specifications 2.10.4(2) and 2.10.4(3). This assures that the products of the radial peaking factors and their appropriate uncertainties are less than the values used in determining the setpoints.

The minimum margin to the kw/ft limit is used to set alarms on all detectors. This imposes restraint on the power distribution as well as the peak linear heat rate and precludes the occurrence of undetected peaks larger than the limit. When in-core detector alarms are set using this method, several alarms would be received in the event of a shift in the power distribution even though the maximum local peak linear heat rate may not be exceeded.

Calibration of the ex-core detector input to the APD calculator is required to eliminate ASI uncertainties due to instrument drift and axially nonuniform detector exposure. If the recalibration is not performed in the period specified, the prescribed steps will assure safe operation of the reactor.

Reference

INCA/CECOR Power Peaking Uncertainty - CENPD-153-P, Revision 1-P-A, May 1980.

6.0 INTERIM SPECIAL TECHNICAL SPECIFICATIONS

6.4 Operation With Less Than 75% of Incore Detector Strings Operable

DELETED

DELETED

DELETED

DELETED

Discussion

The purpose of this change is to permit operation with less than 75% of the incore detector strings operable and to assess the uncertainty penalty which must be applied. Operation with less than 75% of the incore detector strings operable was justified for Cycle 6 in Interim Special Technical Sepcification 6.4. The proposed amendment application incorporates the Cycle 6 interim specification into the main body of the Technical Specifications and stipulates that a cycle specific analysis must be performed whenever implementation is required. The incorporation of this specification will eliminate the need for creating an interim specification during cycles when the 75% operability requirement cannot be met.

Fort Calhoun Station's past experience with Cycle 6 detector failures and the current operability status of Cycle 7 through August 29, 1982, as shown in Figure 1, indicate that the accumulated failures generally should not reach the minimum operability condition until mid-cycle or later, if at all. Minimum operability should not occur sooner, because all inoperable strings (i.e., two or more failed detectors) are replaced during each refueling outage, thus permitting beginning-of-cycle operation with all strings operable.

The mid-cycle or later implementation of the alternate operating mode (i.e., 20 to 75% of the strings operable) corresponds to a burnup when the radial peaking factors, $F_R{}^T$ and $F_{xy}{}^T$, will have decreased to values low enough in magnitude, that even with the application of additional uncertainties, sufficient margin to the Technical Specification limits will exist. When implemented in Cycle 6, as an example, the untilted values of F_R and F_{xy} including a 1.01 multiplier were 1.44 and 1.47 which are well below the Technical Specification limits of 1.52 and 1.57. Figures 2 and 3 show plots of the measured $F_R{}^T$ and $F_{xy}{}^T$ values, respectively, as a function of burnup for Cycle 7. At the August 26, 1982 burnup of 7463 MWD/MTU, the values of $F_R{}^T$ and $F_{xy}{}^T$ were 1.45 and 1.48 which have large margins relative to their respective limits of 1.57 and 1.62.

The methods used in deriving the additional uncertainty (or penalty) to be applied are documented in Reference (1) and are consistent with Reference (2). Reference (3), a letter to the Nuclear Regulatory Commission, provides a copy of Reference (1) and demonstrates the method used to ensure that the assumed uncertainties on F_{xy}, F_q, and F_R remain within their calculated limits.

The Reactor Protection System setpoints remain valid with the proposed change. The functions potentially affected include the kw/ft and departure from nuclear boiling (DNB), limiting conditions for operation (LCO's), and limiting safety system settings (LSSS's). Each of these is addressed below.

The maximum total unrodded radial peaking factor, $F_{xy}{}^T$, that can occur with the CEA's inserted above the power dependent transient insertion limit is factored into the ex-core kw/ft LCO. Periodic monitoring of $F_{xy}{}^T$ using the incore detector system is required to assure that the F_{xy}^T assumptions used in the synthesis of the excore LCO are not exceeded. If F_{xy}^T exceeds the Technical Specification limit (Technical Specification Figure 2-9), the allowed power is reduced to a value for which the kw/ft LCO and LSSS is conservative. For operation with a reduced complement of incore detectors, the allowed limit for F_{xy}^T is penalized by the increased measurement uncertainty to maintain the allowed power.

The maximum integrated radial peaking factor, F_R^T, that can occur with the CEA's inserted up to the power dependent transient insertion limit is factored into the DNB LCO. During the periodic monitoring of F_R^T, using the incore detector system, the F_R^T value must be within the allowed limits of Technical Specification Figure 2-9 to ensure that the assumptions used in the DNB LCO synthesis are valid. If F_R^T exceeds this figure's limit, the allowed power is penalized to a value for which the TM/LP trip and DNB LCO become conservative and valid. For operation with a reduced complement of incore detectors, the allowed limit of F_R^T is penalized by the increased measurement uncertainty, maintaining the allowed power while still ensuring the validity of the DNB LCO and TM/LP trip.

References

1. "Analysis of CECOR Power Peaking Uncertainties for Fort Calhoun Unit 1 Cycle 6", Report CEN-150(O)-P, February 1981.

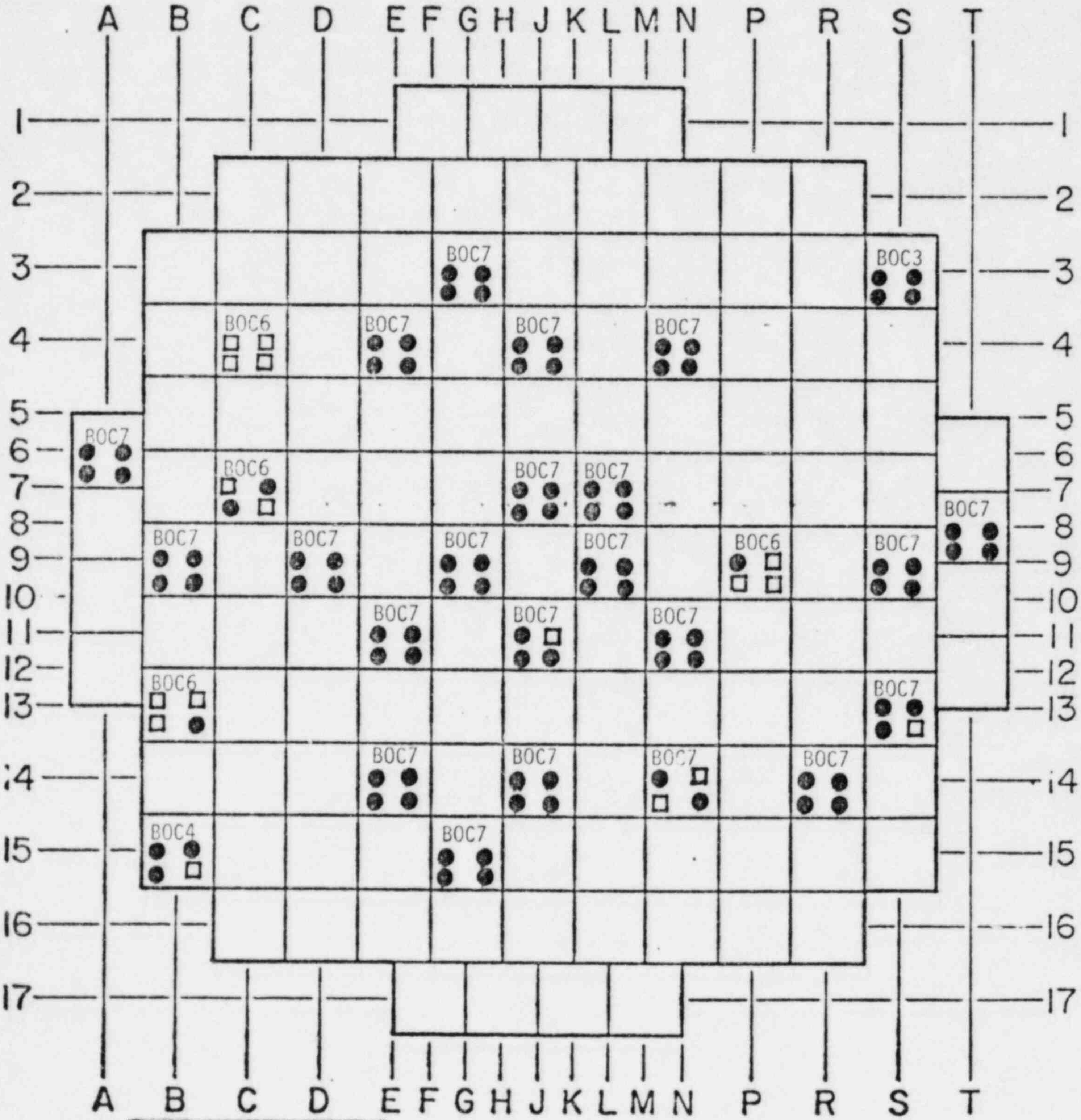
2. "INCA/CECOR Power Peaking Uncertainty", Report CENPD-153-P, Revision 1-P-A, May 1980.

3. Letter from W. C. Jones to Charles M. Trammell, dated April 24, 1981.

CALLED NORTH

CYCLE 7
OPERABLE INCORE DETECTOR STATUS

Figure 1



BATCH

LEVEL 1 LEVEL 3
LEVEL 2 LEVEL 4

● Closed circle indicates operable detectors.

□ Open square indicates failed detectors.

Figure 2

INTEGRATED RAD PEAKING vs BURNUP

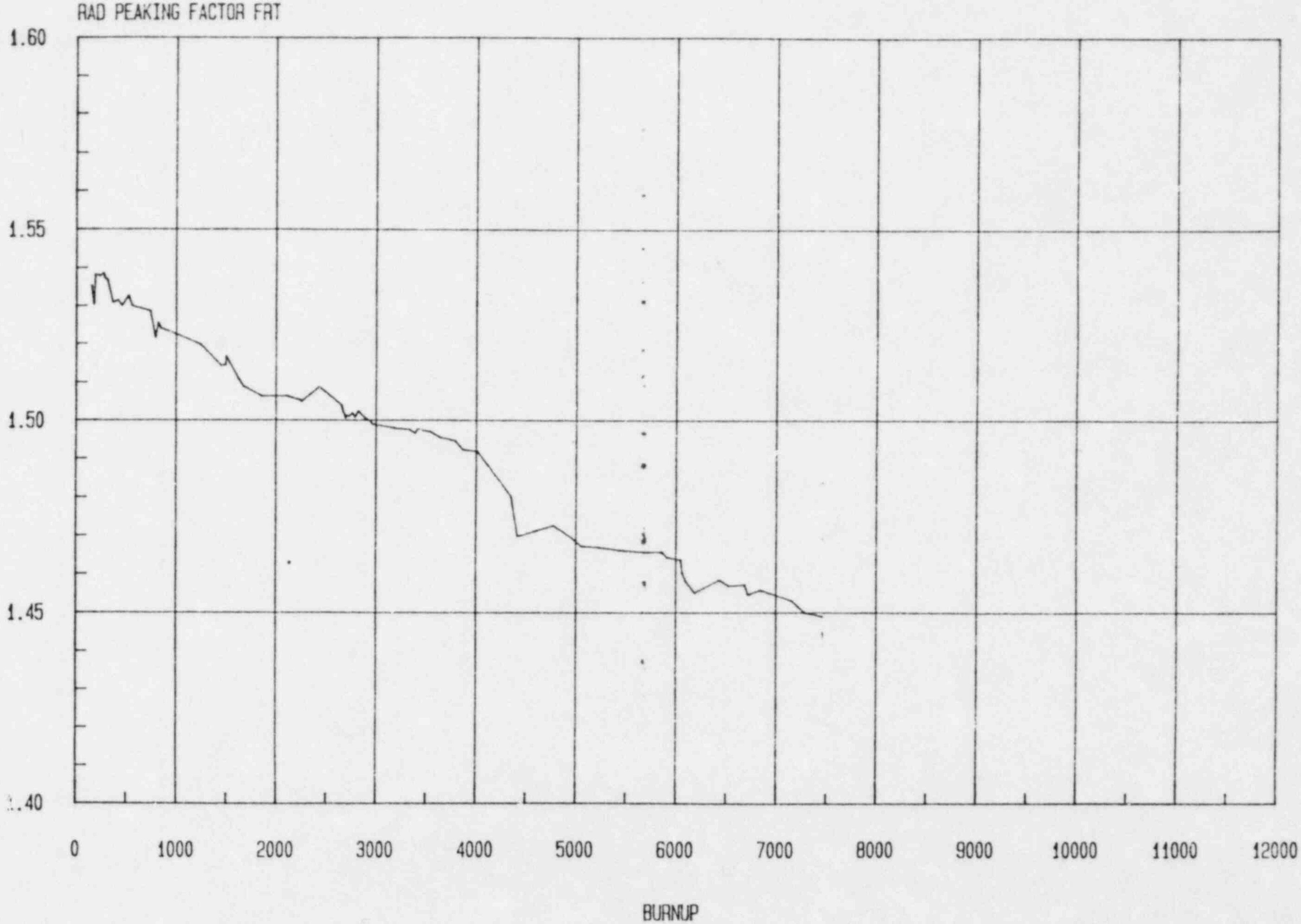
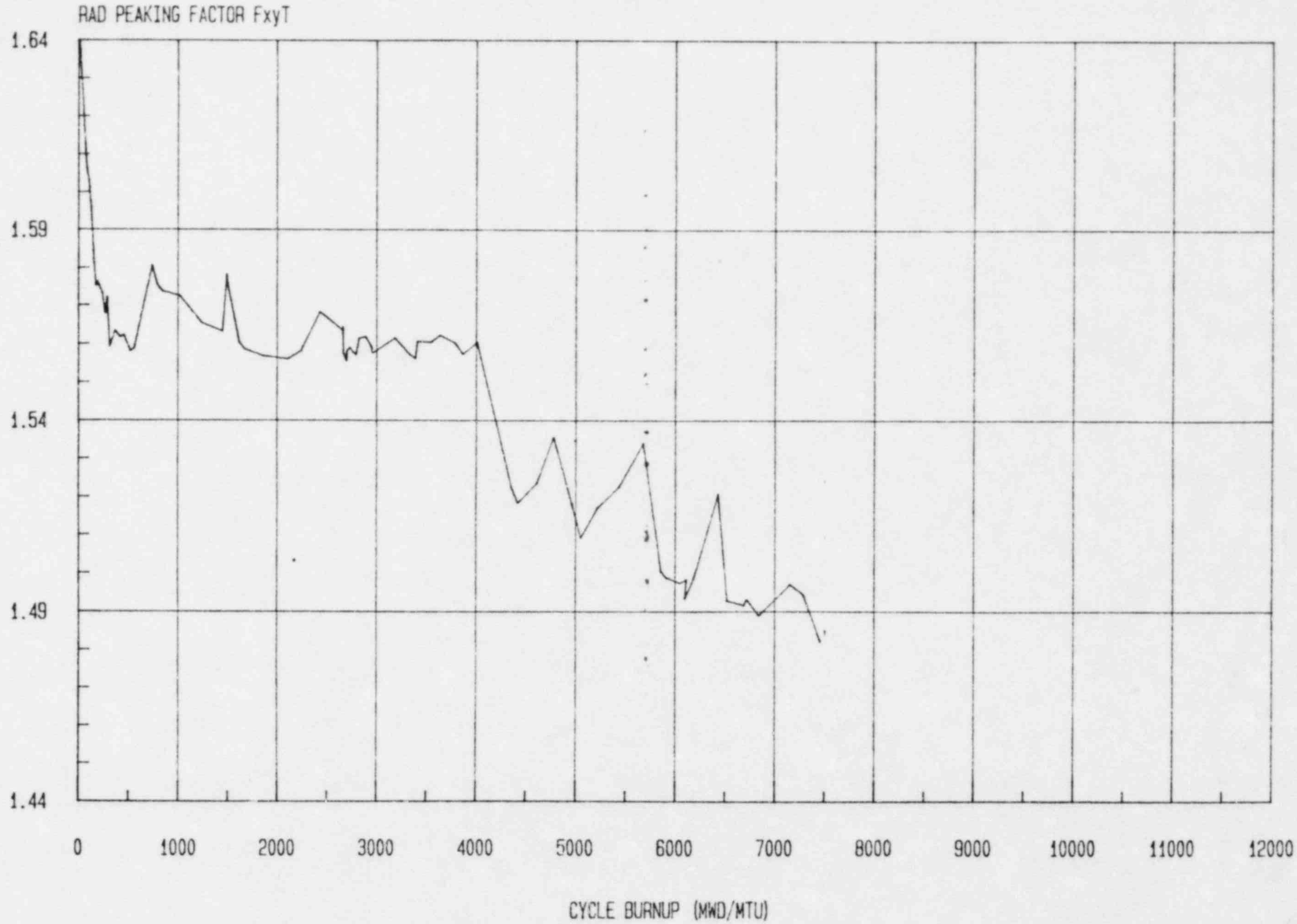


Figure 3

PLANAR RADIAL PEAKING vs BURNUP



FEE JUSTIFICATION

The proposed Facility License Amendment is deemed to be a Class III Amendment within the meaning of 10 CFR 170.22. This determination is made in that it involves only a single safety issue and does not involve a significant hazards consideration.

ATTACHMENT C