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REVIEW OF TOPICAL REPORT CENPD-169-P

Report Title: Assessment of the Accuracy of PWR Operating Limits as Determined by the Core Operating Limit Supervisory System (COLSS)
Report Number: CENPD-169-P (Proprietary)
Report Date: July 1975
Originating Organization: Combustion Engineering, Inc.
Reviewed by: Core Performance Branch, DSS

Summary of Topical Report

The primary objective of CENPD-169-P is to present the methodology for ascertaining the uncertainty in the core power distribution determined by the Core Operating Limit Supervisory System (COLSS) synthesis procedure. In addition, the report serves as a reference for the basic concepts employed to transform the signals from five-level incore detectors into forty-node representations of the radially averaged core axial power shape (CAPS). Also included is a description of the construction of the hot pin and hot channel power distributions using precalculated planar Radial Peaking Factors (RPF) and the CAPS.

The subject report should only be used as a generic reference for the synthesis and uncertainty methodology, since implementation of the methodology and the precise values of the uncertainty factors are plant specific.

Summary of Regulatory Evaluation

The following sections are intended to clarify the essential points pertiment to the evaluation of the CENPD-169-P methodology.

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Applicability of the Report

The COLSS methodology described in the report will generically encompass CE plants of the Arkansas Nuclear One-Unit 2 and future designs. However, the precise value of the appropriate uncertainty factors depend on basically three design parameters: the number and burnup of the fuel assemblies the Control Element Assembly (CEA) programming, and the number of operable incore detectors. Thus the Linear Power Density (LPD) uncertainty will depend on the plant design.

Core Power Distribution

The core axial power shape (CAP) is calculated from the integral responses of 5 levels of incore detector segments. A simple 5 element Fourier fit to the power distribution is employed. Sets of integral detector signal equations are solved for the combining coefficients and the core axial power distribution is constructed for 40 axial nodes. For each reactor employing a COLSS, these coefficients are calculated with a reactor simulator model and are experimentally verified during startup testing.

The detailed radial power distribution is not measured in COLSS. Radial peaking factors calculated with a reactor simulator model (the simulator model is a three dimensional nodal core physics model for the calculation of the core power distribution) are employed to construct the hot pin and hot channel power distribution. The radial peaking factors are functions of CEA configuration and are stored in the COLSS computer. Tests will be performed during the reactor start-up program to verify that the pre-calculated values of radial peaking factors are appropriate for the as-built reactor. Updating of COLSS power distribution constants will be based on the results of the measurement of core power distributions by the INCA (ref. 1) program.

Uncertainty Analysis

The technique described for determining the uncertainty in the COLSS calculated F_Q combines the CAPS synthesis error with the INCA (ref. 1) verified planar RPF uncertainty. To determine the CAPS uncertainty, the F_Q's for more than 4000 core configurations, including steady-state, transients, and non-normal CEA configurations, calculated by the reactor simulator and the COLSS procedures were compared. In these computations, the COLSS procedures employed the planar RPFs obtained from the simulator for each core configuration.

Thus, the differences in F_Q reflect only CAPS synthesis errors. The uncertainty in the RPF's attributable to the accuracy of the INCA (refs. 1 and 2) system used to verify the RPF's is combined with the CAPS uncertainty to yield the total uncertainty value.

The increase in the uncertainty in the COLSS synthesized F_Q as a function of inoperable incore detectors was evaluated. The calculations show that the error is small, even with a large number of inoperable detectors. This is because the axial distribution is obtained from the average of all operable detectors at a given axial level and therefore even a large number of inoperable detectors does not greatly affect the average values.

Regulatory Position

Based on our review of the areas described above, we conclude that the subject report is an acceptable reference for the general methodology of COLSS to determine core power distributions from incore detectors. In addition, the procedure described for calculating the overall uncertainty in F_Q including uncertainties in the COLSS synthesis procedure is satisfactory. The values for uncertainties used in references 1 and 2 are intentionally excluded from this review, since review of those documents has not been completed.

REFERENCES

1. CENPD-145 INCA - Method of Analyzing In-Core Detector Data, April 1975.
2. CENPD-153 Evaluation of Uncertainty in F_Q Measured by Self-Powered Fixed In-Core Detector Systems, August 1974.