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RECIP.NAME RECIPIENT AFFILIATION
CLARK,R.A. Operating Reactors Branch 3

SUBJECT: Forwards description of facility core follow program,in response to NRC 800123 ltr.Any significant changes to program during Cycle 4 will be reported.

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FLORIDA POWER & LIGHT COMPANY

May 9, 1980
L-80-147

Office of Nuclear Reactor Regulation
Attention: Mr. Robert A. Clark, Chief
Operating Projects Branch 3
Division of Project Management
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Clark:

Re: St. Lucie Unit 1
Docket No. 50-335
Cycle 4 Core Surveillance Program

In accordance with an NRC letter dated January 23, 1980, a description of the Florida Power & Light Company Core Follow Program for St. Lucie Unit 1 for Cycle 4 is attached and is submitted to you for information. This program was discussed with the NRC staff at a meeting in Bethesda, Maryland on February 20, 1980; and from subsequent discussion with the staff, we understand that the program is satisfactory. Any significant changes to the program during Cycle 4 will be reported to you in writing.

Yours very truly,

Robert E. Uhrig

Robert E. Uhrig
Vice President
Advanced Systems & Technology

REU/TCG/ah

Attachments

cc: J. P. O'Reilly, Region II
Harold F. Reis, Esquire

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Enclosure A

Description of the FPL Core Follow Program

Florida Power and Light Company routinely conducts a core follow program to ensure that actual core performance is in accordance with design. The analytical models used to perform this function are developed by FPL based upon "as-built" design data and actual assembly burnup distributions developed from incore power distribution measurements. These analytical models are then extensively verified against both vendor supplied data and the startup physics test measurements. These models then become the basis for the FPL "Core-Follow" program.

The method of documentation for the "Core-Follow" program at FPL is to issue a Bi-Monthly Report within two to four weeks following the end of the reporting period. These reports contain detailed analyses of the measured data, and comparisons to calculations performed with the current cycle model. These reports are then sent for information to the Reactor Engineering Supervisor and various technical/engineering groups within FPL. The Reactor Engineering Supervisor and Fuel Management Section Supervisor would be notified if a problem were to be detected during the core follow program. A meeting or telephone call would be held to discuss the characteristics of the perceived problem. The Reactor Engineering Supervisor would then make a determination as to what level of Plant and/or Staff Management would need to be involved in resolving the perceived problem, thereby dictating a course of action.

The Bi-Monthly Reports written for the St. Lucie Plant include but are not limited to the types of comparisons listed in Table 1. An additional comparison will be incorporated in the St. Lucie 1 "core-follow" program for Cycle 4. This evaluation will consist of a comparison of the simulated and measured axial average relative power fraction in instrumented assemblies with intact detector strings on an EFPM schedule. A calculation of the standard deviation of the power weighted difference between simulated and measured values resulting from the comparison will be made. This standard deviation(s), will then be compared to a historical value σ_H=5.25%. This historical value, σ_H, is based upon Cycle 3 data for St. Lucie Unit 1, as described in Enclosure B. If $s > \sqrt{1.31}\sigma_H$ (90% confidence level), the Reactor Engineering Supervisor, and the Fuel Management Section Supervisor will be notified and FPL will have 1 EFPM to resolve the discrepancy. Resolution will consist of a successful test during the EFPM and an explanation of the failure of the previous sample. If $s > \sqrt{1.41}\sigma_H$ (95% confidence level), the Reactor Engineering Supervisor and the Fuel Management Section Supervisor will be notified and an internal review by the Facility Review Group will be initiated. The statistical basis for these criteria are discussed in Enclosure B. The results of these evaluations will be documented in accordance with the Nuclear Analysis Quality Assurance Program and placed in a Quality Record file in the Nuclear Analysis Department. The results of these evaluations will also be included in the Bi-Monthly Report. The Nuclear Analysis Department will maintain the master copy of these evaluations.

TABLE 1

SUMMARY OF FPL CORE FOLLOW PROGRAM
ST. LUCIE UNIT 1

Evaluation Performed	Description of Evaluation Performed	Analysis Frequency
Critical Boron	The measured boron samples are corrected to HFP, ARO, Equilibrium Xenon and compared to the boron letdown curve in the Plant Curve Book.	Monthly
Quarter Core Relative Power Fraction	The measured response data from the incore detectors is analyzed by both, CECOR and the FPL code GAMMA and appropriate comparisons are made between the results of these two codes. The GAMMA results are also compared to the cycle model simulation. The FPL analysis package provides a comparison of the power-weighted difference between the simulated and measured assembly power fractions and calculates the standard deviation resulting from the difference analysis. The standard deviations are trended with cycle burnup in order to indicate significant changes in sample distributions.	Monthly
Peaking Factor Trend Analysis	The following parameters as calculated by both CECOR and GAMMA are compared with the Technical Specification Limits, F^T_{XY}, F^T_R, T_q, LHR and trended with exposure.	Monthly

Enclosure B

Technical Basis For The Core Follow Statistical Test

1.0 Introduction

The relative power distribution test described in Enclosure A is statistical in nature. The goal of the test is to demonstrate objectively with a certain degree of confidence whether or not a sample incore power distribution measurement has significantly deviated from the expected power distribution. This can be accomplished by comparison of statistical parameters associated with the sample to a historical standard.

2.0 Discussion

For the purpose of this test, the algebraic difference between the predicted power fraction and the measured power fraction is treated as a random variable. The distribution of differences constitutes a statistical sample, which comes from an unknown population. Inferences can be made concerning the parameters of the population distribution function and comparisons of sample population distributions based upon establishment of a statistical data base.

The proposed data base consists of 25 incore-power distribution measurements generated by the FPL incore-analysis code GAMMA. The random variable selected is the difference between the axial average measured and calculated power fraction for intact instrumented detector strings to assure independence of the variables. The data covers various power operating conditions from BOC to 5519 EFPH during cycle 3.

From this data, the standard deviation (S_K) for each sample was calculated K=1,...,25. The values for S_K ranged from 4.69 to 5.92 percent and sample size ranged from N=42 to N=33.

The sample distributions were then tested to determine if they came from a common parent population.

This was accomplished by setting up a 25 x 5 contingency table and assigning the observed values for each sample to one of the five cells. The observed values were then compared with their expected values to calculate a Chi-Square statistic. The resulting test statistic was significantly below the $\chi^2_{.95}$(df=24x4) value indicating that each of the samples was from a common parent population.

Determination of the approximate distribution function of the parent population was accomplished by comparing the frequency of the observed value in each of the five cells previously mentioned with the frequency expected if the parent population had been normal. The Chi-Square statistic generated for each sample was significantly below the $\chi^2_{.95}$(df=2) value indicating the assumption of normality was a good approximation of the parent population distribution function.

With the knowledge that the samples come from a common parent population which is normal, the values of the standard deviation (S_K) for each of the samples were pooled (i.e. a weighted average formed) and tested for poolability using the Bartlett test. The resulting test statistic was well below the $F_{.95}$(df=24,df=∞) value indicating that the pooled sample standard deviations could be used to form an unbiased estimate of the parent population standard deviation. The pooled sample standard deviation (S_H) was 5.06%. An upper limit on the population standard deviation (σ_H) with a 95% confidence level can be established as:

$$\sigma_H \leq \sqrt{\frac{S_H^2}{\chi^2_{.05}/df=903}} = 5.25\%$$

Comparison of future sample standard deviations with the historical value of 5.25% will be made to determine if the sample distribution has come from the historical distribution established. This is the null hypothesis and is $H_O: S^2=\sigma^2_H$. Predicated upon the assumption of normality or near normality of future sample distributions, this can be accomplished by use of the statistical F-test at a 90 and 95 percent confidence limit. Indication that the alternate hypothesis is true $H_1: S^2>\sigma^2_H$ will be accomplished at two levels:

a) Indication that the test result warrants further investigation will be $S^2>F_{.90}(V_1,V_2)\sigma^2_H$;

b) An indication that the sample does not come from the historical distribution is: $S^2>F_{.95}(V_1,V_2)\sigma^2_H$.

The degrees of freedom are V_1=39, V_2=903. V_1 is representative of the average number of detectors expected in each sample throughout a cycle, and V_2 is the degrees of freedom used in determining σ_H. The values of $F_{.90}(V_1,V_2)$ and $F_{.95}(V_1,V_2)$ are 1.31 and 1.41, respectively.

Consideration was given to the probability of making a Type II error in the selection of the confidence limits $(1-\alpha)=.90$ and $(1-\alpha)=.95$, where α is the probability of making a Type I error, i.e., the probability of rejecting the null hypothesis H_0 when it is true.

The probability of making a Type II error is β, i.e., the probability of acceptance of the null hypothesis when it is false. The values of β are .05 for α=.10, and .09 for α=.05 for the situation where in truth the sample comes from a population with a variance twice as large as the historical value σ_H^2.

3.0 Summary

In summary, it has been demonstrated that an objective determination of whether or not a sample incore power distribution measurement deviates significantly from what is expected has been developed using a data base composed of distributions which are statistically independent and normal. The method of comparison of sample incore power distributions with the data base will be made through the use of the statistical F-test.

[illegible]