UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION II
101 MARIETTA STREET, N.W.
ATLANTA, GEORGIA 30323

Report Nos.: 50-413/88-16 and 50-414/88-16

Licensee: Duke Power Company
422 South Church Street
Charlotte, NC 28242

Docket Nos.: 50-413 and 50-414 License Nos.: NPF-35 and NPF-52

Facility Name: Catawba 1 and 2

Inspection Conducted: April 18 - 22, 1988

Inspector: P. T. Burnett [signature] 5-2-88 Date Signed

Approved by: F. Jape, Section Chief [signature] 5/2/88 Date Signed
Engineering Branch
Division of Reactor Safety

SUMMARY

Scope: This routine unannounced inspection addressed the areas of review of recently completed post-refueling startup tests, calibration of nuclear instruments, core power distribution monitoring, and followup of open items.

Results: No violations or deviations were identified.

REPORT DETAILS

1. Persons Contacted

   Licensee Employees

   H. B. Barron, Operations Superintendent
   R. G. Blessing, Engineer, Reactor Group
   *S. W. Brown, Reactor Engineer
   *M. A. Cote', Licensing Specialist
   J. W. Cox, Training Manager
   S. L. Cox, Training Specialist
   *T. E. Crawford, Integrated Scheduling Superintendent
   C. L. Hartzell, Compliance Supervisor
   M. W. Hawes, Engineer, Reactor Group
   J. E. Burchfield, Engineer, Nuclear Engineering Services

   Other licensee personnel contacted included security force members, engineers and office personnel.

   Other Organization

   R. L. Wolfgang, Westinghouse

   NRC Resident Inspectors

   *P. K. VanDoorn, Senior Resident Inspector
   *M. S. Lesser, Resident Inspector

   *Attended exit interview

2. Exit Interview

   The inspection scope and findings were summarized on April 22, 1988, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. No dissenting comments were received from the licensee. Proprietary information was reviewed and discussed in the course of the inspection but is not included in this report.

3. Licensee Action on Previous Enforcement Matters

   (Open) Violation 414/87-30-01: Use of incorrect values in the Z and S terms of Technical Specification equation 2.2-1 to determine the acceptability of power range trip setpoints. In their response to the violation dated December 28, 1987, the licensee used correct and acceptable values of the Z and S terms, but their formulation of the R term used the percentage miscalibration value reduced by two percent RTP. They argued that a two percent error was already included in the Z term. The inspector stated that credit could not be taken for the error assigned to the power calorimetric calculation in the setpoint analysis; since that was based upon instrumental uncertainties and did not constitute an available safety margin. The licensee agreed to that restriction, but stated there was additional margin in the setpoint analysis that was appropriate to consider in the R term. They will provide an amended response to the violation by May 15, 1988.

(Open) Unresolved Item 414/86-30-01: Determine the need and establish the guidance for reverifying and documenting system status and test prerequisites for interrupted tests. A response to this issue is now scheduled for June 1, 1988. At the exit interview, licensee management agreed this item had remained open long enough, and appropriate policy would be issued by the stated date.

4. Unresolved Items

No unresolved items were identified.

5. Unit 1 Post-Refueling Startup Tests (72700, 61702, 61705, 61708, 61710)

Initial criticality for Unit 1, Cycle 3 was achieved on December 29, 1987 in accordance with procedure PT/1/A/4150/19, 1/M Approach to Criticality. Under this procedure, dilution of the NC system boron concentration was initiated at 277 gpm with all control and safety rods inserted while monitoring inverse multiplication by calculating and plotting the ICRR for every thousand gallons of dilution water. During dilution, the SRNI countrates doubled. The reduction in boron concentration was from 1831 to 1333 ppmB. (The target endpoint had been 1336 ppmB.) At that point, new baseline data for the inverse multiplication measurement calculations were obtained. Inverse multiplication was calculated and plotted periodically during rod withdrawal.

Good features of PT/1/A/1/4150/19 included turning off the spray flow to the VCT while in alternate dilute mode to prevent over dilution of that tank, and performing ten and three-observation Chi-Squared tests of the SRNIs periodically to assure their proper functioning. Both SRNIs "failed" the test at control bank C at 96 steps. Actually, the failure was probably the result of a non-constant source and an indicator of imminent criticality.

Prior to pulling rods, OP/0/A/6100/06, Reactivity Balance, was performed and a critical position of 60 steps on control bank D was predicted. The actual critical position was seven steps on control bank D. The reactivity difference in the positions was consistent with the difference between the predicted and measured ARO C_B determined later in the test program.

The balance of the startup testing program was performed under the guidance of PT/1/A/4150/21, Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing.

Onscale overlap between the SRNIs and the IRNIs of more than one decade was confirmed.

Two reactivity computers were used. One was designed and manufactured by Westinghouse and the other was an onsite fabrication based upon on IBM 9000 computer. For nominal reactivity insertions of ± 25 and ± 50 pcm, each computer in every case agreed within ± 4% of the value derived from period measurement and the inhour equation.

The point of adding nuclear heat was determined by establishing a slow startup rate, ≈0.2DPM, and allowing flux to increase until heating was observed by an increase in average NC temperature accompanied by a change in the reactivity traces on the computers. The upper flux limit for zero power physics tests was established one decade below the observed point of adding heat. This testing limit was established to prevent doppler feedback effects from invalidating the precise reactivity measurements required for the isothermal temperature coefficient measurement, reference bank worth measurements and other zero power tests.

The ARO C_B was determined to be 1441.4 ppmB, which was in good agreement with the predicted value of 1411 ± 50 ppmB. The boron endpoints for both ARO and safety bank B inserted conditions were obtained using PT/1/A/4150/10. Each endpoint was the average of four measurements, and each set showed good internal consistency. It was noted that the procedure has no provision for adjusting the results for differences between the actual and reference NC average temperature.

PT/1/A/4150/12A, Isothermal Temperature Coefficient of Reactivity Measurement, was performed at ARO. The resulting ITC and MTC were +1.33 and +2.65 pcm/°F, respectively. The latter satisfied the Technical Specification 3.1.1.3 limit of 7 pcm/°F at powers less than 70% RTP. By performance of PT/1/A/4150/20, Temporary Rod Withdrawal Limit Determination, the licensee confirmed that no withdrawal limits were necessary to satisfy the MTC specification at any power level.

A good feature of PT/1/A/4150/12A was the requirement to have the temperature changes exceed 4°F, which was satisfied. The procedure does allow control rod motion (step 6.4 and note after step 12.5) if it does not interfere with the interpretation of the test results.

PT/1/A/4150/11A, Control Rod Worth Measurement by Boron Dilution, was performed to determine the reactivity worth of the reference bank, in this case safety bank B, by boron dilution. That test used the reactivity computers to measure the reactivity added by periodic insertion of the bank during continuous dilution. The procedure requires a dilution rate of approximately 23 gpm to assure a reactivity insertion rate of less than 300 pcm/hr. Examination of the recorded reactivity traces indicated a maximum insertion rate of about 200 pcm/hr.

Then by performance of PT/1/A/4150/11B, Control Rod Worth Measurement by Rod Swap, the worth of each other bank was determined by observing the critical position of safety bank B with that bank inserted. A correction was made to the remaining inserted worth of safety bank B to account for the presence of the test bank, which was not present when the reference bank worth was determined. All measured rod bank worths agreed with their predicted values within ± 15%. The total reactivity worths agreed within 3%, with the measured being higher than predicted.

No value of the differential boron worth was specifically derived from the endpoint measurements for comparison with the predicted value of -9.94 pcm/ppmB. However, a comparison of reference bank worth with that calculated from the measured change in C_B and the predicted worth of the boron was in good agreement.

Power escalation was begun on December 30, 1987, and 100% RTP was attained on January 6, 1988. Power distribution maps obtained at 30 and 50% RTP exhibited QPTRs in excess of 2%. By 80% RTP the tilts had reduced to less than 2% satisfying Technical Specification 3.2.4.

Between 49 and 80% RTP, thirteen quarter core flux maps were obtained for use in the incore-excore nuclear instrument correlation, but only twelve were later used. PT/1/A/4600/05F, Post Refueling Incore and NIS Recalibration, was performed on January 3-4, 1988. Using the licensee's raw data, the inspector independently correlated full-power top and bottom chamber currents for N41 with the incore-measured axial offset. The calculations were performed using a least-squares spreadsheet and the microcomputer program SUPERCALC3 (release 2.1). The correlation coefficients for the top and bottom chambers were 0.967 and 0.979 respectively. The licensee's corresponding values were 0.969 and, 0.983. Licensee values for other chambers ranged from 0.969 too 0.986. To perform the analyses, chamber currents were first normalized to 100% RTP. Only four of the twelve sets of data were obtained at power in excess of 70% RTP. The need for considerable power normalization may account for the relatively poor fit of the data. A plot of the inspector's analysis is given in Attachment 2. The licensee stated the routine incycle periodic test to perform the incore-excore correlation was performed less than thirty days into the cycle to address their own concerns on the quality of fit.

Three days after reaching full power, NC flow as indicated by the elbow taps became marginal, and power was reduced to 97.5% RTP in accordance with Technical Specification Figure 3.2-3. Subsequently, a change in the specification was approved by NRR to allow full power operation with flow as low as 387600 gpm.

No violations or deviations were identified.

6. Unit 2 Post-Refueling Startup Tests (72700, 61702, 61705, 61708, 61710)

Unit 2 startup test procedures performed between March 7 and March 30, 1988 were virtually identical to those used earlier in the Unit 1 startup and were performed by essentially the same personnel with some interchange in roles. The measured ARO MTC was 2.94 pcm/°F in acceptable agreement with the predicted value of 1.94 ± 3 pcm/°F. The measured ARO C_B was 1349 ppmB, which was in good agreement with the predicted value of 1370ppmB. The comparison between measured and predicted reference bank worths was equally as good at 1258 and 1279 pcm, respectively. The sum of the measured rod bank worths exceeded the predicted by four percent.

No power tilts were encountered during power escalation, and NC system flow exceeded the minimum requirements.

The incore-excore nuclear instrument correlation was based upon twelve quarter core flux maps obtained between 52 and 79% RTP. The correlation coefficients were fair at best, ranging from 0.974 to 0.989. Once power had stabilized at 97% RTP, the test was repeated using seven flux maps obtained at axial offsets ranging from +5.3 to -6.6% RTP. The correlation coefficients were much better, ranging from 0.992 to 0.999. The better fit is demonstrated in Attachment 3.

No violations or deviations were identified.

7. End of Life Moderator Temperature Coefficients (61708)

The measurement of the MTC within seven days of reducing NC C_B below 300 ppmB was reviewed for the last cycle for each unit. The procedures used were PT/1(2)/A/4150/12B, End of Life Moderature Temperature Coefficient, which are essentially identical.

The basis of each test was to hold power constant while changing NC average temperature by first increasing and then decreasing C_B. No use is made of a reactivity computer, instead the boron change and calculated boron worth were used to measure reactivity. The measured at-power MTCs were -24.6 and -16.8 pcm/°F, respectively and satisfied Technical Specification 3.1.1.3.b.

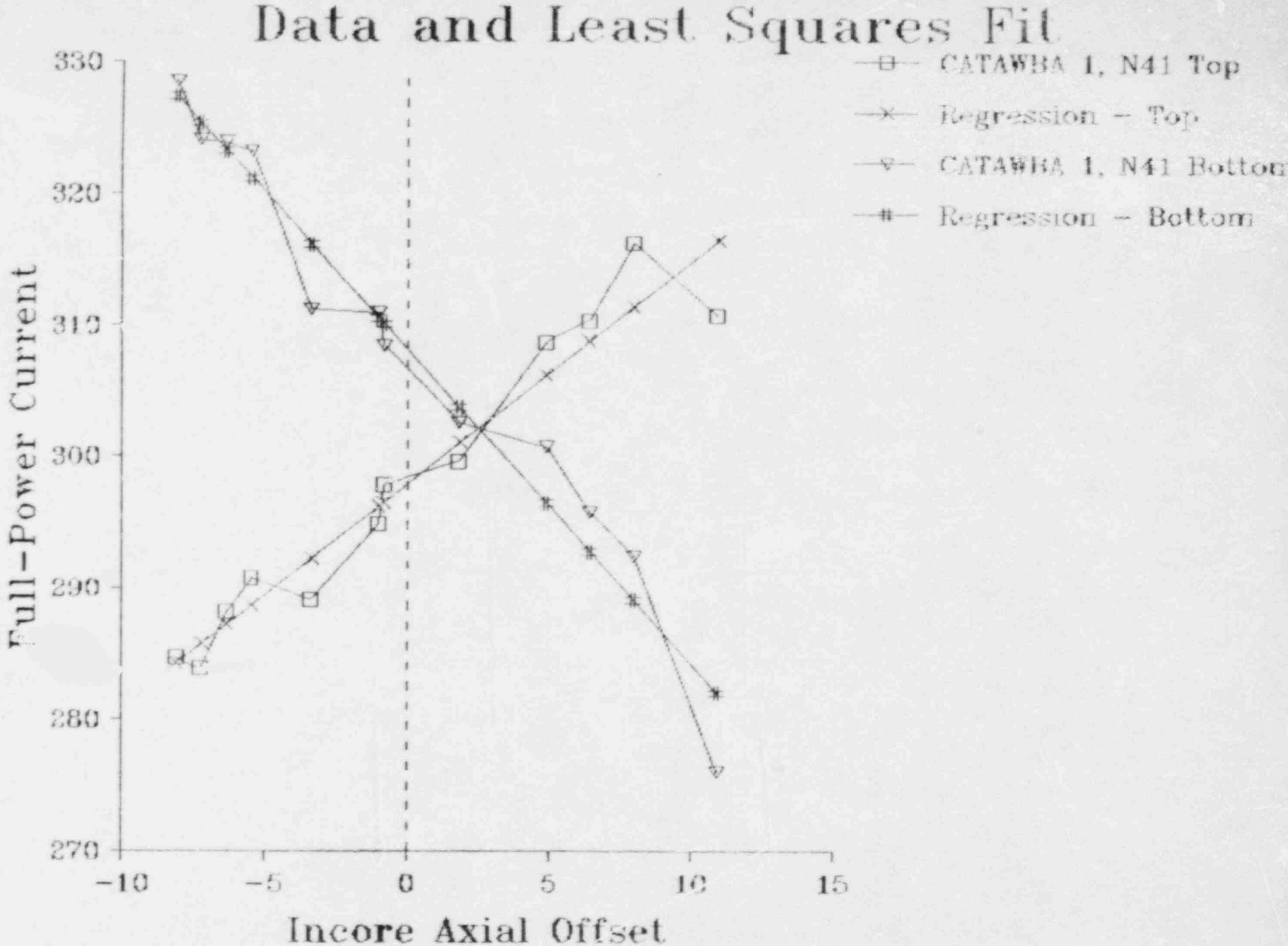
No violations or deviations were identified.

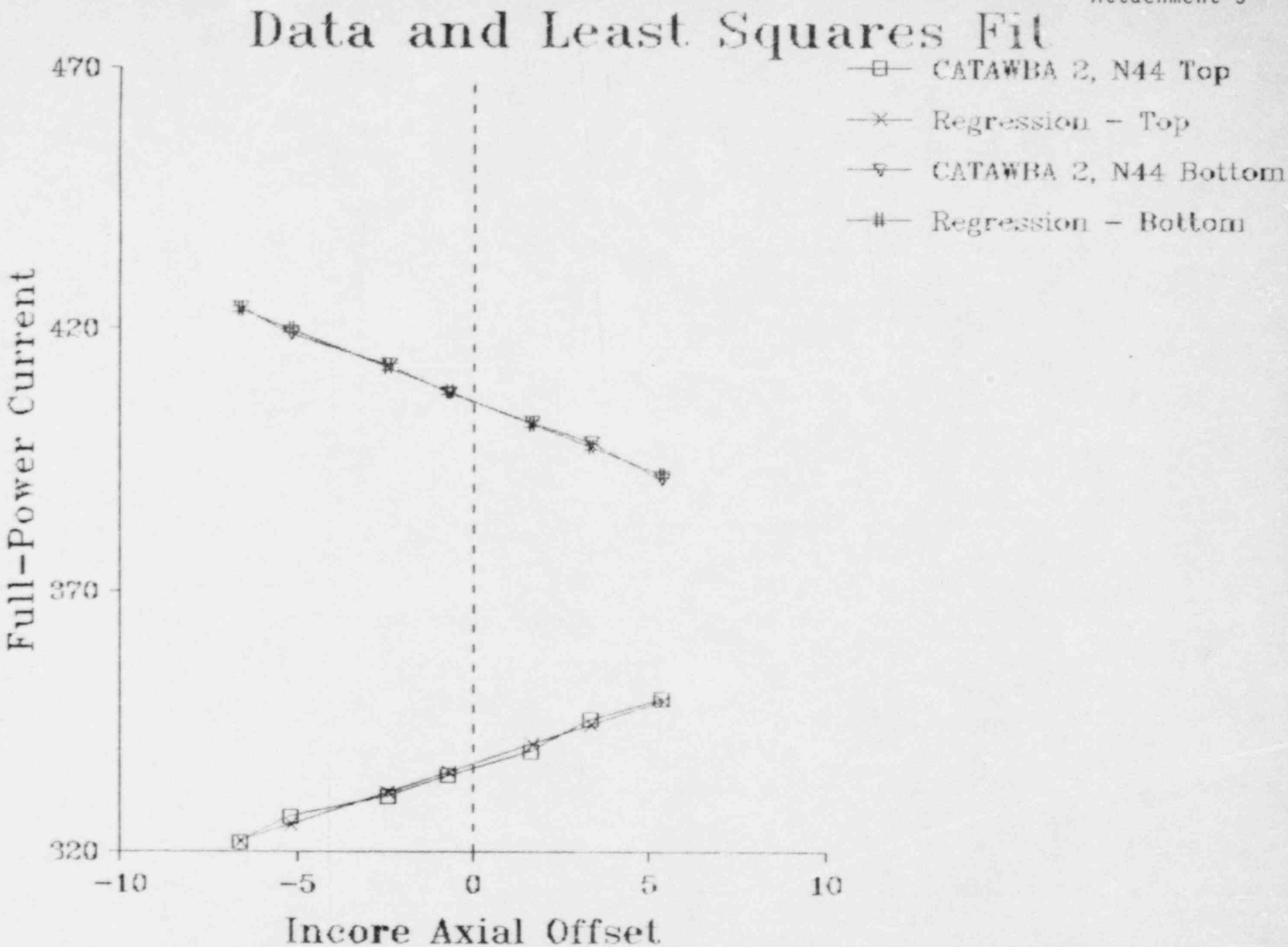
Attachments:
1. List of Acronyms and Initialisms
2. First Incore-Excore Correlation Unit 1, Cycle 3
3. Second Incore-Excore Correlation Unit 2, Cycle 2

Attachment 1

List of Acronyms and Initialisms

1/M - Inverse Multiplication
ARO - All Rods Out
C_B - Boron Concentration in Reactor Coolant
DPM - Decades Per Minute
gpm - Gallons Per Minute
ICRR - Inverse Count Rate Ratio
IRNI - Intermediate Range Nuclear Instruments
ITC - Isothermal Temperature Coefficient
MTC - Moderator Temperature Coefficient
NC - Nuclear (Reactor) Coolant (System)(Nomenclature Unique to this Licensee)
NRR - Office of Nuclear Reactor Regulation
OP - Operating Procedure
pcm - Percent Millirho (Unit of Reactivity)
ppmB - Parts Per Million Boron
PT - Periodic Test (Procedure)
QPTR - Quadrant Power Tilt Ratio
RTP - Rated Thermal Power
SRNI - Source Range Nuclear Instrument
VCT - Volume Control Tank


Data and Least Squares Fit
CATAWBA 1, N41 Top
Regression - Top
CATAWBA 1, N41 Bottom
Regression - Bottom
Full-Power Current
Incore Axial Offset
330
320
310
300
290
280
270
-10
-5
0
5
10
15


Data and Least Squares Fit
CATAWBA 2, N44 Top
Regression - Top
CATAWBA 2, N44 Bottom
Regression - Bottom
Full-Power Current
470
420
370
320
-10
-5
0
5
10
Incore Axial Offset