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

Report Nos.: 50-369/85-20 and 50-370/85-21

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

Docket Nos.: 50-369 and 50-370 License Nos: NPF-9 and NPF-17

Facility Name: McGuire 1 and 2

Inspection conducted: May 21-24, 1985 and June 3-7, 1985

Inspection at McGuire Nuclear Station near Huntersville, North Carolina.

Inspectors: Frank Jape 6/20/85
for C. A. Patterson Date Signed

P. A. Taylor 6-20-85
for P. T. Burnett Date Signed

M. Thomas 6-20-85
for W. T. Orders Date Signed

Approved by: Frank Jape 6/20/85
Frank Jape, Section Chief Date Signed
Engineering Branch
Division of Reactor Safety

Summary

Scope: This special inspection involved (90) inspection hours on site after the reactor startup on May 17, 1985, when the reactor was taken critical below the control rod insertion limits required by Technical Specification 3.1.3.6. The predicted critical rod position was calculated to be 38 steps on bank D, but actual critical position was 26 steps on bank C, which was below the insertion limit of 47 steps on bank C. The primary source of error was attributed by the licensee to be errors in the xenon calculation.

Results: Three violations were identified: (1) Technical Specification 6.8.1.a - Failure to follow procedure for Reactivity Balance Calculations (Estimated Critical Rod Position OP/0/A/6190/06) and failure to follow procedure for reactor startup (OP/2/A/6100/01 and OP/2/A/6100/05) (paragraphs 5.c and 5.d), (2) 10 CFR 50 Appendix B, Criterion V - Failure to review changes to the Xenon Predict Program values used in estimated critical control rod position calculations and shutdown margin calculations, (paragraph 5.e), (3) Technical Specification 6.10.1.d - Failure to retain records of Surveillance Requirement 4.1.1.1.1.e for calculation of shutdown margin (paragraph 5.f).

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*T. McConnell, Station Manager
G. Cage, Superintendent of Operations
*B. Hamilton, Superintendent of Technical Services
*G. Gilbert, Operations
*R. Clark, Duke Nuclear Engineering
W. Reeside, Operations
*M. Pacetti, McGuire Safety Review Group
*W. McDowell, Duke Licensing
W. Jefferies, Duke Nuclear Engineering
R. Phillips, Operations
D. Marquis, Performance Engineer
*S. Brown, Reactor Engineering
*M. Kitlan, Reactor Engineering
*E. McCraw, License and Compliance Engineer

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

*Attended exit interview on May 24 and June 7, 1985

2. Exit Interview

The initial inspection scope and findings were summarized on May 24, 1985, with those persons indicated in paragraph 1 above. Two violations and two unresolved items were identified during the first part of the inspection. The followup inspection resulted in one of the unresolved items becoming a violation and clearing of the other. These results were discussed in an exit interview on June 7, 1985. The licensee acknowledged understanding of the issues discussed and took no exceptions to the violations.

a. Violation 370/85-21-01: Failure to follow procedures, paragraphs 5c and 5d

b. Violation 369/85-20-01, 370/85-21-02: Failure to review procedures changes, paragraph 5e.

c. Violation 369/85-20-02, 370/85-21-03: Failure to retain records, paragraph 5f.

Proprietary material was reviewed during this inspection, but is not incorporated in this report.

3. Licensee Action on Previous Enforcement Matters

This subject was not addressed in this inspection.

4. Unresolved Items

Unresolved items were not identified during this inspection.

5. Followup of Critical Rod Position Prediction Error

This special inspection was devoted to followup of the reactor startup on May 17, 1985, when the reactor was taken critical below the rod insertion limit of Technical Specification 3.1.3.6.

a. Sequence of Events

Time Hour	Date	Event
1149	5/5/85	Initial criticality for Unit 2 Cycle two
0430	5/8/85	Zero power physics testing complete
0617	5/8/85	Entered Mode 1 (> 5% power)
0648	5/8/85	Reactor trip from 10% power
1312	5/8/85	Reactor critical (virtually xenon free - no problems experienced)
0924	5/16/85	Reactor trip from 96% power from failure of non-safety related power generation equipment
0609	5/17/85	Reactor critical below insertion limits Predicted: 38 steps on bank D Actual: 26 steps on bank C Insertion limit: 47 steps on bank C
1149	5/17/85	Reactor critical (xenon value in question, but no changes made to procedure) Predicted: 228 steps on bank D (plus a 205pcm deficit, i.e. subcritical) Actual: 90 steps on bank D
1344	5/17/85	Generator on line and power escalation continued

b. Discussion of Xenon (Xe) Values

Since the beginning of operation of McGuire 1 and 2 the licensee has felt that the vendor (Westinghouse) underestimated peak and equilibrium Xe values. This was based on past experience and surveys of other utilities. A value different from the vendor peak value by 1000 percent millirho (pcm) was used for Unit 2 cycle two. The values used for Unit 2 cycle two for peak and equilibrium Xe were the same values used for Unit 1 cycle two, due to similar core designs.

Discussions with the corporate nuclear engineering staff revealed that the general office usually underpredicts the vendor Xe values and the plant reactor engineering group supplies a multiplier to the general office values for values used in the plant computer. The plant values are usually greater than the vendor supplied values. The general office felt that the library of cross sections and decay constants (EPRI library) used in their computer code (PDQ - a two dimensional diffusion theory code) underpredicted the actual Xe values in the core. Also, it was felt that the vendor estimates have improved lately due to changes in the vendor codes and updated library. This would account for the values used by the plant after 5/17/85 being similar to the vendor values.

Further checking by the reactor engineering group on 5/22/85 found that the values used in Unit 1 cycle two were in error. The values were changed in error in August 1984, based on an estimated critical on bank D instead of the correct value using bank C. The Xe values were changed to more closely predict estimated critical rod position. This error was carried over into Unit 2.

c. Licensee Analysis of 5/17/85 Event Performed on 5/17/85

The previous calculations of critical position were checked and found correct. Boron samples were also verified as correct.

The plant nuclear engineer assigned to handle the missed estimated critical position concluded that the error was due to Xe. This was based on several things. First, the startup on 5/8/85 was essentially Xe free and no problems were noted. Other parameters in the reactivity balance used to calculate critical position were recently verified during startup physics testing (control rod and boron worths). This startup was the only startup in the cycle with significant amounts of Xe, and the time elapsed between the trip and startup involved estimating Xe on the peak Xe curve from the decay of iodine following a reactor trip. Previous estimates of Xe had been a source of debate and a measurement of Xe in this cycle had not been performed.

Review of the nuclear instrument chart recorder traces was performed on June 6-7, 1985, at the request of the inspectors. That review revealed that the startup rate on 5/17/85 at 0600 hours had been faster than the 1.0 decade per minute (dpm) specified by the plant procedures, specifically OP/2/A/6100/01, Controlling Procedure for Unit Startup (item 2.3), and OP/2/A/6100/05, Unit Fast Recovery (item 2.1). The licensee's evaluation of the rate was 1.3 dpm, and the inspectors calculated 1.8 dpm. Failure to follow procedure was identified as a violation of Technical Specification 6.8.1.a which requires that written procedures shall be established, implemented, and maintained for operating procedures, Violation 370/85-21-01, Failure to follow procedures.

d. Restart on 5/17/85

For the restart at 1149 hours on 5/17/85, a new estimated critical rod position was calculated using plant procedure Reactivity Balance Calculation, Enclosure 5.2 of OP/0/A/6190/06. An estimated position of 228 steps on bank D was calculated. This is all rods out. Step 9 of the procedure yielded a negative number for the reactivity worth of rods to be inserted and a negative value required an estimated critical boron calculation per Enclosure 5.1. This would have required a boron dilution but the results of the enclosure were ignored and a procedure change not initiated to update the Xe values believed to be in error. The procedure had been checked by a second licensed operator.

The dilution was ignored due to the fact that the engineer believed the Xe to be in error and a dilution would have resulted in a possible repeat of the criticality below the insertion limits. The Xe worth was thought to be 717 pcm less than as previously used. The boron concentration also had been increased by 227 ppm. Using these values the critical position was estimated by the engineer to be around 100 steps on bank D. The actual critical position was 90 steps on bank D. In effect, the procedure was used to estimate critical rod position and was used as a test to determine Xe worth.

Failure to follow procedure was identified as a second example of the violation of Technical Specification 6.8.1.a, which requires that written procedures shall be established, implemented, and maintained for operating procedures (370/85-21-01). This violation was discussed with plant management in the exit meetings on 5/24/85 and 6/7/85.

e. Computer Changes after the Startup to Correct Xe Values

The value for Xe worth used in step 3 of OP/0/A/6190/06 comes from a computer program. Changes were initiated to the plant off-line computer which were not in accordance with normal procedures. Normally, the corporate nuclear engineering staff reviews these changes and after approval the computer technicians make the changes.

On 5/17/85 the changes were made to the off-site (corporate) computer first by computer technicians and then mailed to corporate for approval. Discussions with corporate personnel revealed that they were initially unaware of the event and first learned of the event days later from another facility.

The on-line (process computer) was updated with new Xe values on 5/22/85. Changes to the plant computers are made with a Production Technical Services Service Request Routing and Approval Form (Form 34744 (12-81)). This form requires approval by a technical sponsor. The reviews of these forms in the past had not identified any errors in Xe values.

Subsequent analysis of the process through which the Xenon Follow/Predict program is changed revealed some concerns, which are detailed below.

Changes to the Xenon Follow/Predict program were made without performing a Nuclear Safety Evaluation of the change. There have been at least five recent changes to this program, none of which had an associated Nuclear Safety Evaluation until May 24, 1985.

1) June 29, 1984 (Initial cycle values)
2) July 9, 1984 (Change to near vendor values)
3) Sept. 11, 1984 (Error introduced)
4) April 24, 1985 (Unit 2 cycle two initial values)
5) May 17, 1985 (Correction)

The evaluation for the May 24, 1985, change was performed five days after the change had been implemented. In an effort to determine why the evaluations had not been performed, it was determined that the licensee did not recognize that changes to the computer calculated values were considered to be a procedure change. Administrative Policy Manual 4.2.4.1.e requires all procedures changes to receive a nuclear safety evaluation prior to use. Since the calculation derived from the computer program are directly employed in procedure OP/O/A/6190/06 Reactivity Balance Calculation for determining estimated critical positions and shutdown margins, which are safety-related determinations, the change should receive the same considerations of technical viability and safety implications as any other change to a safety-related procedure. Any change, therefore, should be preceded by a Nuclear Safety Evaluation.

The failure to implement Nuclear Safety Evaluations for changes to the referenced computer program is a violation to the requirements of 10 CFR 50 Appendix B criterion V. Activities affecting quality are required to be accomplished in accordance with instructions or procedures appropriate to the circumstances which embody the necessary acceptance criteria to ensure the satisfactory accomplishment of the task. Data such as the Xe values used in the procedure are required to be technically valid and receive the same review and

approval as the procedure in which it is employed. This is violation 50-369/85-20-01, 50-370/85-21-02, Failure to review procedure changes.

f. Inspector Review of Shutdown Margin Calculations

The inspector reviewed the shutdown margin calculation performed on 5/17/85 prior to the 1149 hours startup on May 17, 1985, and found that by using the inflated Xe values in the procedure, errors resulted in the nonconservative direction. The procedure, Shutdown Margin - Unit Shutdown, Enclosure 5.5, allows taking credit for the Xe worth in the shutdown margin and estimates a time that boration would be required as the Xe decays. The time was determined to be 2100 hours using the inflated Xe values and 1700 hours using the Xe curve with the updated Xe values.

The inspector requested a review of all past shutdown margin calculations performed since the introduction of the Xe error in Unit 1 cycle two. These records were not available. The licensee performed the surveillance calculation but was retaining only the shutdown margin value and not retaining the data used to perform the calculation. The inspector stated that this practice was inconsistent with record retention requirements for surveillances required by Technical Specifications. The records for the shutdown margin surveillance, as required by T.S. 4.1.1.1.1.e, while in modes 3, 4 and 5 for the period August 1984 to June 1985 were unavailable. With the reactor in mode 3, 4, or 5 the shutdown margin is required to be determined once every 24 hours considering the following factors:

1) Reactor coolant system boron concentration
2) Control rod position
3) Reactor coolant system average temperature
4) Fuel burnup based on gross thermal energy generation
5) Xenon concentration
6) Samarium concentration

The Technical Specification requirement is implemented in Station Directive 2.1.1 attachment 5, Document Retention Requirements, which requires a six year retention of completed safety-related permanent station procedures that involve documentation of compliance with acceptance criteria. The failure to retain the records was identified as violation 50-369/85-20-02 and 50-370/85-21-03.

g. Licensee Reconstructed Data for Shutdown Margin

The licensee was able to reconstruct some of the data used for determination of shutdown margin. A review of these data was performed to determine if the required shutdown margin had been reduced. This review was conducted using the updated Xe values and minimum boron concentration following reactor trips or shutdowns from the time the peak Xe error was introduced in August 1984 for Unit 1

cycle two. A check was made to determine if the decay of Xe reduced the shutdown margin. The licensee also stated that the shutdown boron concentration curve contained a 100 ppm (1000 pcm) safety factor.

The results of the review revealed that on 2/5/85 the reactor trip was 23 ppm short of the required shutdown margin but, by using the 100 ppm safety factor, 77 ppm was available before the shutdown margin was violated. Also, for the shutdown on 11/23/84 and cooldown on 11/24/84 it could not be determined if the required boration took place prior to or after cooldown due to the lack of records of boron sampling times.

The results of the review were not made available for the inspectors review until 6/6/85. The inspectors questioned the source and basis of the 100 ppm safety factor. The safety factor is built into the vendor supplied table for the shutdown boron concentration. Discussion with the vendor revealed the safety factor is introduced because of known uncertainties in the vendor calculations such as control rod worths, and boron worth, and that the safety factor is not an additional margin available to the licensee. A vendor engineer offered the opinion that approximately 25 ppmB excess margin was available because measured boron concentrations at McGuire were consistently less than the predictions of the Westinghouse calculations.

h. Review of Unit Trip on 6/1/85 and Startup on 6/2/85

The reactor trip of Unit 2 cycle two at 0919 hours on 6/1/85 and startup on 6/2/85 was reviewed for estimated critical rod position problems. At the time of startup, after the trip, the value of the Xe worth was greater than 100% power equilibrium. The startup was conducted using the corrected Xe values implemented after 5/17/85 (near vendor values). The estimated critical rod position was within 500 pcm of the actual rod position and no problems were noted during the startup.

i. Summary and Conclusions

The corporate nuclear engineering staff conducted an evaluation of taking the reactor critical below the rod insertion limits and identified two safety parameters of concern - the available shutdown margin and the ejected rod worth. The shutdown margin for Unit 2 at 0600 hours on May 17, 1985 was found to exceed the required margin. The ejected rod worth was within that analyzed in the Reload Safety Evaluation.

The startup procedure should have been revised prior to the second startup when it was found to be incorrect. Further, inadequate reviews of reactivity parameters used in estimated critical rod position and shutdown margin calculations led to the problem of taking the reactor critical below the rod insertion

limits, exceeding the startup rate limit prescribed by procedure and the possibility of nonconservative errors in the shutdown margin calculations. The lack of plant records of previous shutdown margin calculations made the review process difficult. A complete review of this event was not conducted by the licensee until prompted by the inspectors.

6. Post-Refueling Startup Tests Unit 2 Cycle Two (72700)

The following post-refueling startup tests for Unit 2, cycle two were reviewed:

a. PT/0/A/4150/21, Post Refueling Controlling Procedure for Criticality, Zero Power Physics, and Power Escalation Testing. The test was approved on April 25, 1985 and performed on May 4-24, 1985. The impact of core alterations on excore detector signal was evaluated and found to be acceptable (step 8.3). The predicted shutdown margin at the rod insertion limit was 3115 pcm, considerably in excess of the minimum required of 1300 pcm (step 8.4). The shutdown margin for the rod-swap tests (reference bank in) was acceptable (step 8.5). More than one decade of overlap between the source-range and intermediate-range nuclear instruments was demonstrated, enclosure 13.2. Using enclosure 13.3 the point of adding nuclear heat and the upper power limit for zero-power testing were established. Performance of the reactivity computer was compared against stop-watch period and reactivity measurements for reactor instrumentation using enclosure 13.4, and found to be acceptable.

b. PT/0/A/4150/28, Criticality Following a Change in Core Nuclear Characteristics. The test was approved April 24, 1985, and performed on May 4-5, 1985. The chi-squared statistical test was used to confirm proper operation of the source range detectors used in providing input for the inverse multiplication calculations that guided the approach to criticality.

c. PT/0/A/4150/10, All Rods Out Boron Endpoint Measurement, was approved on April 26, 1984 and performed on May 5-8, 1985. The predicted all-rods-out boron endpoint concentration was predicted to be 1491 +/- 50 ppmB. The measured result was 1423 ppmB, which was outside the numerical acceptance limits. The result was evaluated by Westinghouse, at the request of the licensee and found to be acceptable.

d. PT/0/A/4150/12A, Moderator Temperature Coefficient of Reactivity during Startup Mode. The test was approved on April 26, 1984. It was performed for all rods out on May 6, 1985 and with bank D in on May 7, 1985. Although the results were acceptable, the inspector noted that the differences in results between heatup and cooldown measurements were greater than observed in the past. The temperature increments were only one degree F. Larger increments would yield more consistent results, and would be compatible with the fuel vendor's recommendations for startup tests.

e. PT/O/A/4150/11, Control Rod Worth Measurement, was approved on April 26, 1984. It was performed on May 6, 1985, for control bank C, which was to be used as the reference bank in later rod-swap measurements. The reactivity computer traces were independently evaluated by the inspector, and good agreement with licensee values (within 0.2 pcm per increment) was obtained. The measured worth was 871 pcm, which was in acceptable agreement with the predicted value of 908 +/- 91 pcm.

f. PT/O/A/4150/11A, Control Rod Worth Measurement, Rod Swap, was approved on April 30, 1984, and was performed over the period May 6-7, 1985. All measured worths met the acceptance criterion of less than 30% or less than 200 pcm difference from prediction.

g. PT/O/A/4150/02A, Core Power Distribution, was approved on April 19, 1985. The first measured power distribution at 100% power was performed on May 15-18, 1985. All thermal and power distribution limits were satisfied.

h. PT/O/A/4600/02E, Incore and NIS Recalibration: Post Outage, was approved on May 25, 1984, and performed on May 10-12, 1985. The results of eleven quarter-core flux maps were analyzed using a computer program to obtain the correlation between the individual chamber currents of the power range detectors and axial offset. The program does not perform an evaluation of the quality of fit of the data to the correlation line. The licensee stated that the results are also plotted by hand and a visual evaluation of the reasonableness of the results performed. The inspector had no further questions regarding this practice.