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

Report Nos.: 50-327/91-05 and 50-328/91-05

Licensee: Tennessee Valley Authority
6N 38A Lookout Place
1101 Market Square
Chattanooga, TN 37402-2801

Docket Nos.: 50-327 and 50-328 License Nos: DPR-77 and DPR-79

Facility Name: Sequoyah Units 1 and 2

Inspection Conducted: March 4-8, 1991

Inspector: P. T. Burnett 22 March 1991
P. T. Burnett Date Signed

Approved by: B. A. Breslau for Mar 25 1991
L. J. Watson, Section Chief Date Signed
Operational Programs Section
Operations Branch
Division of Reactor Safety

SUMMARY

Scope:

This routine, unannounced inspection addressed the areas of incore power distribution monitoring and trending of hot leg streaming parameters in Unit 1, review of recently completed startup tests for Unit 2, cycle 5, and excore nuclear instrument calibrations in both units.

Results:

The licensee has been trending the hot leg RTD indications, streaming factors, and apparent reactor differential temperature against power and time. Now, at mid-cycle, no trends are obvious, with the possible exception of the streaming factor (variation of RTD temperatures within one leg). The inspector reviewed the changing power output of forty of the peripheral assemblies, those expected to have the greatest effect on streaming. The relative power output of these bundles has changed very little, and linear extrapolation of the current trend to end of cycle predicts only a small (about 7%) increase in power production of these bundles, which currently have a normalized power output of about 0.6 times average. It does not appear that the incore power distribution will change enough to induce any change in streaming factor sufficient to obtain a correlation between the two. The inspector also analyzed some of the incore thermocouple maps. The average temperature of the ten coldest thermocouples has increased only slightly from -30°F below the average outlet temperature to -24°F below average. Thus there is no immediate prospect of measuring a

mixed mean hot leg temperature, true vessel delta temperature, or the primary coolant system flow rate. However, the apparent delta temperature, obtained by averaging the three hot-leg RTDs in each loop, varies proportionately to power, with little if any temporal effect. Therefore, safety systems, such as over temperature and over power delta temperature calculated trips, are capable of performing the prescribed safety functions. However the inability to measure primary coolant flow rate for the foreseeable future is of concern; since flow rate is a parameter of the safety analysis and is anticipated to decrease as a function of impeller wear and steam generator tube plugging. The licensee is considering placing external thermocouples on the circumference of the hot legs to obtain a better understanding of the streaming phenomenon. That instrumentation would be added during the next refueling outage. (Paragraph 2)

The test results for the Unit 2, cycle 5 startup were all acceptable. Each test showed clear evidence of independent peer review; since numerous corrections for numerical errors were entered into the documents. The reactor engineering staff capability is improving. (Paragraph 3)

The licensee has improved the quality and frequency of incore-excore nuclear instrument correlation tests. The quality increase was in response to an earlier violation. The frequency increase is a licensee initiative and is commendable. (Paragraph 4)

Two violations from an earlier inspection were closed. (Paragraph 5)

REPORT DETAILS

1. Persons Contacted

Licensee Employees

*R. Alsop, Audit Manager
*M. Brooks, Site Quality Assurance
*M. Cooper, Site Licensing Manager
D. Craven, Plant Staff
R. Fortenberry, Program Manager for Plant Manager
J. Gates, Technical Support Manager
*M. Meade,Compliance Engineer
R. Mooney, Plant Staff
L. Pruett, Operations Support
W. Pruett, Quality Assurance
*J. Proffitt, Compliance Licensing Manager
*R. Rogers, Technical Support Program Manager
R. Thompson, Licensing Engineer
*M. Skarzinski, Reactor Engineering Manager
C. Vondra, Plant Manager
*J. Wilson, Site Vice President

Other licensee employees contacted included engineers, operators, and office personnel.

Other Organizations

*C. Dumsday, Westinghouse

USNRC Resident Inspectors

*P. E. Harmon, Senior Resident Inspector
S. M. Shaeffer, Resident Inspector

*Attended exit interview on March 8, 1991

Acronyms and initialisms used throughout this report are listed in the final paragraph.

2. Incore Power Distribution and Hot-Leg Streaming Effects (61702)

During initial full power operation of Unit 1, cycle 5, the licensee determined that the hot-leg RTDs (three per loop at 120° angular spacing) were not responding uniformly in any of the loops and that the individual loop-average hot-leg temperatures were higher than expected. Consequently, the vessel delta-Ts were higher than expected. The latter led to an initial interpretation that RCS flow was less than expected or allowed. Other measurements, such as RCS elbow tap dPs and steam pressure at full power, argued against a flow reduction in the RCS, and it was concluded that the loop RTDs were not measuring the loop mixed-mean temperature either individually or when averaged. The source of the streaming in the hot legs was postulated to be a non-uniform core outlet temperature distribution exacerbated by the low-leakage core. Data from cycle 1 indicate that the core outlet thermocouples all indicated in a band of ± 5°F about the mean. In the current core, some outlet thermocouples are as much as 30°F below the mean. Apparently, these diverse substreams are not well mixed at the point of hot leg temperature measurement.

The licensee has been trending the hot leg RTD indications, streaming factors, and apparent reactor differential temperature against power and time. Now, at mid-cycle, no trends are obvious, with the possible exception of the streaming factor (variation of RTD temperatures within one leg). Turbine performance parameters over the same period have been essentially constant, with a very slight downward trend, which might be indicative of feedwater venturi fouling.

The inspector reviewed the changing power output of forty of the peripheral assemblies, those expected to have the greatest effect on streaming. The relative power output of these bundles has changed very little, and linear extrapolation of the current trend to end of cycle predicts only a small (about 7%) increase in power production of these bundles, which currently have a normalized power output of about 0.6 times average. It does not appear that the incore power distribution will change enough to induce any change in streaming factor sufficient to obtain a correlation between the two.

The inspector also analyzed some of the incore thermocouple maps. The average temperature of the ten coldest thermocouples has increased only slightly from -30°F below the average outlet temperature to -24°F below average. Again, there is no unambiguous trend, which might be correlated with hot leg streaming and any changes in average hot leg temperature or loop delta-T.

Thus there is no immediate prospect of measuring a mixed mean hot leg temperature, true vessel delta-T, or the primary coolant system flow rate. However, the apparent delta-T, obtained by averaging the three hot-leg RTDs in each loop, varies proportionately to power, with little if any temporal effect. Therefore, safety systems, such as over temperature and over power delta-T calculated trips, are capable of performing the prescribed safety functions. However the inability to measure primary coolant flow rate for the foreseeable future is of concern; since flow rate is a parameter of the safety analysis and is anticipated to decrease as a function of impeller wear and steam generator tube plugging. The licensee is considering placing external thermocouples on the circumference of the hot legs to obtain a better understanding of the streaming phenomenon. That instrumentation would be added during the next refueling outage.

To date, however, the understanding of the flow streaming problem has not advanced over that provided in the TVA letter of June 18, 1990, "SEQUOYAH NUCLEAR PLANT (SQN) - UNIT 1 CALORIMETRIC". In an attachment to that letter, TVA provided a justification for continued operation, but the period of validity of that justification has not been determined.

The incore flux maps reviewed had been performed with acceptable frequency and results to satisfy the hot channel factor surveillance requirements of TS.

No violations or deviations were identified.

3. Post-Refueling Startup Tests (72700, 61708, 61710)

   a. Precritical Activities

      The inspector reviewed the following documents and completed procedures related to precritical activities for Unit 2, cycle 5:

      (1) WCAP-12713, Nuclear Parameters and Operations Package for Sequoyah Unit 2, Cycle 5, issued November 1990 (NUPOP). One difference in this document from that for previous cycles is that SDM is established for a post-trip cooldown to 541°F instead of just to the no-load average RCS temperature of 547°F.

      (2) 2-PI-NXX-092-001.0, Prestartup NIS Calibration Following Core Load, was performed in the period from October 31, 1990, to November 17, 1990. Calculation of power range constants was performed in section 6.1. This is a comparison of the predicted power distribution at the start of the new cycle to the last measured power distribution of the last cycle. Only the three fuel assemblies with the most influence on a PRNI are considered in the comparison. The predicted distribution, based upon an assumed quarter-core symmetry, was obtained from the NUPOP. The last measured power distribution, with no symmetry assumed, was used to obtain specific correction factors for each PRNI.

      The correction term for the IRNIs is derived from the output of four fuel assemblies. The test engineer apparently misread the predicted power for the symmetric (Y-) assembly as 0.51 vice 0.61 and calculated the new power fraction as 1.63 instead of 1.79. This error was conservative with respect to setting the IRNI trip setpoints, but the existence of the error indicates a lack of adequate peer review of that procedure. The IRNIs were subsequently calibrated against a heat balance; so the error did not persist.

      (3) RTI-1 (Revision 13), Restart Test Sequence, scheduled the activities of the reactor engineering group throughout the refueling outage. It also provided the acceptance criteria for each scheduled test.

   b. Initial Criticality and Zero Power Testing

      The inspector reviewed the following completed procedures related to low power operations and testing for Unit 2, cycle 5:

      (1) RTI-3.1 (Revision 1), Initial Criticality, was initiated on November 11, 1990, from an initial boron concentration of

1762 ppmB. Shortly after criticality, RCP seal leakage required a maintenance outage. The test was repeated in its entirety, beginning on November 20, 1990, from an initial boron concentration 1550 ppmB. For both startups, there was a rigorous checkout of each SRNI using the chi-squared statistical test. After criticality, the licensee established the zero power testing range below nuclear heating prior to proceeding with further testing.

(2) TI-25 (Revision 18) Setup and Operation of The Reactivity Computer, was reviewed with particular attention to Appendix G, "Installed Reactivity Computer Dynamic Response Check." By comparison with off-line solutions of the inhour equation using stop-watch measured periods, correct response of the reactivity computer was confirmed over the range from -39 pcm to +42 pcm. Reviews of tests, which used the reactivity computer, confirmed that the applications were limited to the calibrated range.

(3) RTI-4 (Revision 6), Boron Endpoint Determination and Isothermal Temperature Coefficient Measurement, determined the C_B at ARO, corrected to 547°F, was 1527 ppmB vice the predicted (NUPOP) value of 1558. The acceptance criterion of agreement within 10% was satisfied.

The measured ITC, corrected to ARO and 547°F, was -2.90 pcm/°F, and was in acceptable agreement with predicted (NUPOP) value of -3.6 pcm/°F. The acceptance criterion was in agreement within 3 pcm/°F. Uncorrected ITCs for heatup and cooldown agreed within 1 pcm/°F. The corresponding MTC was -1.0 pcm/°F at 547°F and -0.48 pcm/°F at 541 °F. The procedure recommends temperature changes between 547 and 542 (delta T = 5 °F). Actually both the heatup and cooldown swings were less than 3°F, which is not a good implementation of the procedure. This method is endpoint error dependent; the percentage error or uncertainty of the measurement is reduced by increasing the temperature span. In this case, there is no question of not satisfying the TS requirement that the MTC be negative, but the licensee staff did agree that better implementation of the procedure would be necessary in the future, when more confidence in the test might be needed.

(4) RTI-5 (Revision 4), Rod Bank Worth Measure using Dilution/Boration Method, was performed on November 20, 1990, for control bank D only, since it was the be the reference bank for the subsequent rod swap measurements. The measured result of 1102.7 pcm was in good agreement (2.1%) with the predicted worth of 1080 pcm.

(5) RTI-7 (Revision 6), Rod Worth Measurement using Rod Swap, was used to measure worth of all of the remaining control and safety banks. The measured results ranged from -7.5% to -1.7% of the predicted results. Total measured rod bank worth was 4852.3 pcm, which was 3.34% less than the predicted sum of 5020 pcm. The acceptance criterion of 10% agreement was satisfied.

c. Summary

With the one exception noted above, the completed tests all showed evidence of thorough and effective peer review. That review was successful in identifying and correcting numerous errors in reading numbers from charts and curves, transcription errors, and errors in simple arithmetic. The consistent cause of the errors appeared to be lack of attention to detail on the part of the responsible engineer. The licensee has established a training program to improve the quality of startup and surveillance tests performed by the reactor engineers. Review of more recent surveillance tests, discussed elsewhere in this report, indicates the training program is being successful.

No violations or deviations were identified.

4. Incore-Excore Nuclear Instrument Correlations (61702)

The inspector witnessed part of a performance of procedure 0-PI NXX-092-001.0 (revised by interfiling ICF 90-0498), Incore-Excore Detector Calibration. The reactor engineers performing the test were familiar with the test requirements and the procedure and were performing the test carefully and methodically.

The inspector reviewed recently completed copies of this procedure and found them acceptable; a minimum of four flux maps were obtained for each correlation. The licensee has improved the quality and frequency of incore-excore nuclear instrument correlation tests. The quality increase was in response to an earlier violation. The frequency increase is a licensee initiative and is commendable.

No violations or deviations were identified.

5. Followup of Previous Open Items (92701, 92702)

a. (Closed) Violation 50-327 and 50-328/90-29-01: Failure to provide a correct procedure for prestartup calibration of the PRNIs.

The licensee admitted the violation in their letter dated November 15, [illegible] Corrective action for Unit 2 has been completed by issuance of Revision 1 to procedure 2-PI-NXX-092-001.0, which was used during the startup of Unit 2, cycle 5. Revision of the corresponding procedure for Unit 1 is scheduled to be completed prior to the next refueling outage for Unit 1. That schedule is acceptable.

b. (Closed) Violation 50-327 and 50-328/90-29-02: Failure to follow procedures:

(1) During an incore-excore nuclear instrument correlation, an insufficient number of flux maps were taken and the power level at the time of the correlation was much less than the specified level.

(2) Required independent verifications were not signed off.

The licensee admitted the violation in their letter dated November 15, 1990, and the following corrective actions have been completed:

(1) Procedure 0-PI-NXX-092-001.0 was revised by interfiling ICF 90-0498. The revision assures that a minimum of four flux maps, including at least one full core map, are performed during each measurement. Review of recently completed procedures confirmed that the revised procedure was being properly performed. Further, on advice of the fuel vendor, the licensee has increased the frequency of performance of this procedure, which is commendable.

6. Exit Interview (30703)

The inspection scope and findings were summarized on March 8, 1991, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspection findings. Proprietary information was reviewed in the course of the inspection, but is not contained in this report.

7. Acronyms and Initialisms Used in This Report

ARO	All rods out
BOC	Beginning of cycle
C_B	RCS boron concentration
delta-T	Temperature rise through the core or vessel
DP	Differential pressure
EOC	End of cycle
HFP	Hot full power
HZP	Hot zero power
ICF	Instruction Change Form
ICRR	Inverse count rate ratio
IRNI	Intermediate range nuclear instrument
ITC	Isothermal temperature coefficient
MTC	Moderator temperature coefficient
NUPOP	Nuclear Plant Operations Package
pcm	percent millirho, a unit of reactivity
ppmB	parts per million boron
PRNI	Power range nuclear instrument
RCS	Reactor coolant system
RTD	Resistance temperature device
RTP	Rated thermal power
SDM	Shutdown margin
SRNI	Source range nuclear instrument
T-average	The average reactor coolant temperature in the vessel
TS	Technical Specifications