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

Report Nos.: 50-327/92-01, 50-328/92-01

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: January 6 - 10, 1992

Inspector: P. T. Burnett 2/20/92 Date Signed

Approved by: R. V. Crlenjak, Chief 2/19/92 Date Signed
Operational Programs Section
Operations Branch
Division of Reactor Safety

SUMMARY

Scope:

This routine, unannounced inspection addressed the review of Unit 1, cycle 6, startup tests and initial operation, calibration of RTDs used in the EAGLE 21 system, flow streaming induced anomalies in the overpower delta-temperature alarm system, and routine core performance surveillances of both units.

Results:

The startup tests for Unit 1, cycle 6, appeared to have been performed well, with results that were in good agreement with predictions in most cases. However, two areas of concern were identified in the review and will be tracked as inspector followup items pending resolution. Those items are:

- Control the boron concentration in the volume control tank during use of the alternate dilute mode of operation to avoid over dilution (paragraph 2.b).

9203100227 920220
PDR ADOCK 05000327
Q PDR

- Review the acceptance criteria for control rod reactivity worth measurements to assure consistency with assumptions used in shutdown margin analysis (paragraph 2.f).

Problems with start-of-cycle calibrations of resistance temperature devices appear to have been resolved by relocation of the data collection device in the measuring circuit (paragraph 3).

Oscillations in the measured average hot-leg temperatures, which led to periodic alarms in the overpower differential temperature circuit, were determined to be the result of the incore power distributions created by the low-leakage core design. The oscillations are not driven by fuel design (VANTAGE 5H) or the temperature measuring and averaging system (EAGLE 21) (paragraph 4).

Routine core performance surveillance results were satisfactory for both units (paragraph 5).

One previous unresolved item was closed (paragraph 6).

No violations or deviations were identified

REPORT DETAILS

1. Persons Contacted

Licensee Employees

J. Bynum, Vice President, Nuclear Operations
R. Beecken, Plant Manager
G. Buchanan, Technical Support
M. Cooper, Site Licensing Manager
*T. Flippo, Quality Assurance/Quality Engineering Manager
J. Gates, TSS Manager
M. Lorek, Operations Superintendent
*W. Lagergren, Operations Manager
*R. Lumpkin, Site Quality Assurance Manager
*H. Rogers, Acting Technical Support Manager
*R. Thompson, Compliance Licensing Manager
*R. Rausch, Modification Manager
*M. Skarzinski, Reactor Engineering Manager
*J. Smith, Regulatory Licensing Manager
*J. Wilson, Site Vice President
*C. Wittemore, Licensing Engineer

Other licensee employees contacted included engineers and office personnel.

NRC Resident Inspectors

*E. W. Holland, Senior Resident Inspector
*S. M. Shaeffer, Resident Inspector
R. D. McWhorter , Resident Inspector

*Attended exit interview on January 10, 1992.

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

2. Unit 1, Cycle 6, Startup Tests (61705, 61708, 61710, 72700)

Prior to the cycle 6 startup, the licensee had revised all startup test procedures except for TI-25, Reactivity Computer Calibration.

For the cycle 6 startup test program, the inspector reviewed the test log maintained by the test directors and the following completed test procedures:

a. 0-RT-NUC-000-001.0 (Revision 0), Restart Test Program, became effective just before the start of core alterations, and controlled all major plant evolutions associated with plant restart through full power operation.

b. 0-RT-NUC-000-003.0 (Revision 0), Initial Criticality, was performedby fully withdrawing all safety rods and control rods until approximately 100 pcm remained in D bank. Rod withdrawal was monitored by ICRR every 50 steps. Then the RCS was diluted to criticality at a rate of about 50 ppmB/hr. ICRR was plotted against time, dilution water added, and measured C_B. Criticality was achieved in a well-controlled manner. Subsequently, the minimum flux level for nuclear heating was determined and the upper limit for zero power physics tests was established about one-half decade lower in flux. A dynamic test of the reactivity computer was completed using TI-25. Reactivity computer solutions agreed with inhour equation solutions within ± 4% for reactivities ranging from -26 pcm to +39 pcm.

Some questions and observations arose in the review of the procedure, which were discussed and resolved with the appropriate licensee managers. These questions or observations included:

(1) Step 3.0 I recommends 1000 counts per observation to assure good counting statistics for the ICRR determinations using the SRNIs. Step 3.0 J requires statistical evaluation of countrate data. However, Appendix B was performed at average observed counts of 269 and 472 respectively for N-31 and N-32. The averages of these ten-second counts were used as the initial values for the ICRRs. The inspector independently performed a chi-squared analysis of the licensee's data, with good results, but the short total time of the data collection period did not give a good test of long term SRNI stability.

The statistical tests were not performed for the new base count rates for the dilution process. However, the licensee did average three ten-second counts for each new base rate. The inspector's chi-square analyses for those observations were acceptable.

(2) The abstract for this procedure gives an operator precaution: "Improve mixing in the VCT by bypassing the VCT during dilution and using a large and small letdown orifice." Discussions with the licensee confirmed that the intent of the caution is to use the alternate dilute mode of dilution water addition, in which part of the flow goes directly to charging pump suction. However, the flow to the VCT spray is not shutoff by this procedure, nor is there a specific requirement to make charging flow greater than dilution flow. Without these additional controls on the dilution process, experience has shown that a reactivity overshoot may occur during the subsequent mixing process. The overshoot can challenge the PDIL. Furthermore, it has been postulated, in the PRA analysis for another facility, that restart from a station blackout with a dilute

VCT may lead to a more severe reactivity transient.

The licensee is considering changes in their use of the alternate dilute mode. Their resolution of the issue will be tracked as IFI 50-327 and 50-328/92-01-01.

c. 0-RT-NUC-000-004.0 (Revision 0), Boron Endpoint and Isothermal Temperature Coefficient Measurement, included two measurements of the C_B at ARO, which yielded 1466 and 1469 ppmB. Those results satisfied the acceptance criterion, but not the review criterion. Westinghouse reviewed the measured results and found them acceptable.

The heatup and cooldown traces of reactivity versus temperature for the ITC measurement were remarkably free of noise, and the results for the two measurements of -3.68 pcm/°F and -4.0 pcm/°F, respectively, satisfied the acceptance criterion for internal agreement within 1 pcm/°F. The average ITC, corrected for D-bank position and temperature, was -3.34 pcm/°F at 541°F.

0-SI-NUC-000-139.0 (Revision 1), Measurement of Beginning of Life Moderator Temperature Coefficient, was performed in conjunction with the ITC measurement. After correcting for a doppler coefficient of -1.8 pcm/°F, an MTC of -1.54 pcm/°F, at 541°F, was obtained. The measured MTC satisfied the BOL/ARO/HZP limit of -1.18 pcm/°F specified in the COLR. This limit is more restrictive than the usual requirement that the MTC be $\leq$ 0.0; because the early cycle depletion of burnable absorber material is expected to exceed the depletion of fissile material. The COLR limit assures that the MTC will be negative throughout cycle 6.

d. 0-RT-NUC-000-005.0 (Revision 0), Rod Bank Worth Measurement Using Dilution/Boration Method, was used to determine the worth of control rod bank D, which was to be used as the reference bank in the rod swap measurements. The inspector independently evaluated the reactivity computer traces for the measurement and obtained differential reactivities and integral reactivity in close agreement with those reported by the licensee.

The reported integral worth of 964.5 pcm was within the acceptance criterion of 969±145 pcm. However, this 15% allowance about the predicted value exceeds the 10% allowance specified in ANSI/ANS- 19.6.1-1985, Reload Startup Physics Tests for Pressurized Water Reactors, Table A-1, Recommended Test Criteria, and is not consistent with the assumption in SDM calculations that rod worth is measured with ±7% precision.

e. 0-T-NUC-000-007.0 (Revision 0), Rod Worth Measurement Using RodSwap, yielded excellent agreement between measured and

Test Criteria, and is not consistent with the assumption in SDM calculations that rod worth is measured with ±7% precision.

e. 0-T-NUC-000-007.0 (Revision 0), Rod Worth Measurement Using RodSwap, yielded excellent agreement between measured and predicted worths for all banks, with the magnitude of the errors ranging from .05% to 3.2%. The acceptance criteria for agreement between measured and predicted values of rod worth were the larger of ±200 pcm or ±30% of the predicted value. These tolerances, which were obtained from the topical report: WCAP-9863-P-A (May 1982) Rod Bank Worth Utilizing Bank Exchange, are double those of ANSI/ANS- 19.6.1. Furthermore, the tolerances are much larger than the agreement usually experienced either at this facility or at comparable facilities. It appears that these acceptance criteria greatly exceed those expected from properly conducted measurements compared with adequately modeled calculations, in addition to being inconsistent with assumptions of measurement precision used in the SDM.

f. 0-RT-NUC-000-008.0 (Revision 0), Low Power Physics Testing Acceptance Criteria, provided the source of the acceptance criteria discussed above under the specific tests. The acceptance criterion for the sum of the measured control rod worths was that the sum exceed 93% of the sum of predicted worths. That criterion is consistent with the assumptions in SDM calculations; however, a similar criterion appears appropriate to the reference bank measurement, because all other measurements of control rod worth are dependent upon it. Adequate control of test performance might be better assured by using acceptance criteria for the rod swap measurements from the ANSI/ANS standard, modified by the assumptions of precision used in the SDM analysis.

This procedure also contains SDM acceptance criteria, which require that the sum of the rod-bank worths not exceed 110% of the predicted sum. A limit of 107% would appear to be more consistent with the assumptions used in the SDM calculations.

The licensee's response to these observations of acceptance criteria for control rod worth measurements will be tracked as IFI 50-327 and 50-328/92-01-02.

g. 0-PI-NUC-092-081.0 (Revision 1), Pre-Startup Nuclear Instrumentation System Calibration Following Core Load, was performed over the period from November 1, to December 4, 1991. The procedure assures that the pre-startup calibrations of the PRNIs and IRNIs conservatively account for the predicted changes in core power distribution and neutron leakage characteristics from the end of the previous cycle to the beginning of the present cycle.

No violations or deviations were identified.

3. Problems Using the Data Logger with EAGLE 21 (61701, 61705)

Although Westinghouse specified a DMM for obtaining data for RTD recalibration, for cycle 6, TVA chose to use a data logger to obtain contemporaneous data on all RTDs. That would assure that all RTDs were recalibrated under identical plant conditions. If the RTD data were obtained serially at each temperature plateau, then there would be no assurance that the unit was at exactly the same temperature for each observation at that plateau.

The logger was specified for a 20 Mohm input impedance to match that of the DMM recommended by Westinghouse. However, the logger is capacitively coupled to the test signal, which interacts with the capacitively isolated test points of the Eagle 21 system. The charging and discharging of the capacitors introduced noise, non-systematically, to the data logger. Thus, the data obtained for recalibration of the RTDs lacked the necessary precision to generate an acceptable curve fit. This problem was not detectable until all the data were collected and Unit 1 was at operating temperature.

The interim corrective action was to increase the uncertainty in RTD accuracy, which, concomitantly, decreases the allowed delta T operating band specified in TS Table 2.2-1, Notes 3 and 4. Currently the smaller band is being controlled administratively, but a TS change is being prepared for submission to NRR in February 1992.

Further testing of the data logger has demonstrated that it may be installed upstream of EAGLE 21 with no adverse effect on the measurements or performance of EAGLE 21. With Unit 1 operating, it has not been possible to obtain data for recalibration of the RTDs. If a unit cooldown is required, the data will be obtained.

Plans have been made to fully test the new logger installation in Unit 2 once it enters MODE 3 to start the March 1992 refueling outage. However, the testing to date justifies confidence that the incompatibility between the data logger and EAGLE 21 has been resolved.

No violations or deviations were identified in the review of these activities.

4. Unit 1 Reactor Coolant Flow Measurement and Hot-Leg Streaming (61701, 61702, 61705)

TS 4.2.5.2, requires that the RCS total flow rate shall be determined by measurement at least once per 18 months. Unlike the specifications for more recently licensed units, this specification does not require that the flow measurement be obtained from a precision, secondary-side heat balance, and the BASES for the Sequoyah specification are mute on the measurement method. The licensee's difficulties in measuring average hot-leg temperature and in inferring RCS flow have been discussed in previous inspection reports (90-29 and 91-05) for this facility. Consequently, the licensee has changed the RCS flow surveillance procedure to eliminate dependence on the precision heat balance and direct measurement of the average hot leg temperature.

0-SI-SXX-068-155.0 (Revision 1), Reactor Coolant Flow Verification, was performed on December 25-26, 1991, at greater than 50% RTP. The procedure does not use a current heat balance. Instead, RCS flow was measured from the cold-leg, elbow-tap dPs only. Repetitive measurements of dP were averaged and compared with the cycle-1 dPs on a loop-by-loop basis. The following equation was solved for each loop:

$W = W_1*(V*dP/V_1*dP_1)^{½}$, where the subscript 1 refers to cycle 1 data, no subscript refers to the current cycle, V is the specific volume of the water, and W is the volumetric flow rate.

The cycle 1 determination of flow rate (W_1) was based upon a precision heat balance; the elbow taps were not subject to any other calibration process.

The flow measured by this procedure was 381,886 gpm, which was in excess of the TS 3.2.5.c limit of 378,400 gpm, but slightly less than the baseline measurement. Relative to baseline values, loops 1 and 2 flows increased slightly, while both loop 3 and loop 4 decreased slightly in flow.

In response to the apparent decrease in flow, trip setpoints were increased from 89.4 to 89.6% flow. FSAR Table 15.1.3-1 (Sheet 1) lists the loop flow trip as 87% of loop flow.

There are other problems with hot leg temperature measurements apparently related to coolant streaming effects, which result from a change in incore power distribution for cycle 5 to cycle 6. The measured average hot leg temperatures for loops 1 and 4 are oscillating continuously and oppositely in steady state operation. The variations in loop 1 were sufficient to generate turbine run back alarms from the OPdT circuit. Consequently, the unit was being held at ~98% RTP, at the time of this inspection. Remedies being considered included increasing the alarm setpoint. Reportedly, this has been done at Vogtle and Millstone, neither of which is an EAGLE 21 plant, but which had similar problems. Another consideration was to remove the one percent conservatism in the delta-T_o for the system. Another consideration was to remove one of the three hot leg RTDs from the T_H calculation.

Over the longer term, changes in the equations in TS may be considered. Starting with cycle 7, the core will be all VANTAGE-5H fuel, and a mixed fuel penalty in K_4 can be removed.

It must be emphasized that the temperature oscillations and hot-leg streaming phenomena are not created by either VANTAGE-5H fuel or the EAGLE 21 RTD monitoring system. The problems are driven solely by the low leakage core design and the resulting incore power distribution.

No violations or deviations were identified.

5. Units 1 and 2, Routine Core Surveillance Activities (61702, 61708)

   a. Hot Channel Factors

      Completed copies of 0-SI-NUC-000-126.0 (Revision 0), Hot Channel Factor Determination, were reviewed for the last six months of cycle 5 for Unit 1 and for the current, cycle 5, for Unit 2. In all cases the frequency of surveillance, the number of detector paths used, and hot channel factors satisfied the surveillance requirements.

   b. End-of-Life Moderator Temperature Coefficient

      0-SI-NUC-000-007.0 (Revision 0), Measurement of the At-Power Moderator Temperature Coefficient, was performed for Unit 1, cycle 5, on June 13, 1991, at a RCS C_B of 286 ppmB. MTCs measured during heatup and cooldown were in acceptable agreement at -25.3 pcm/°F and -30.2 pcm/°F, respectively.

      This procedure was performed on Unit 2, cycle 5, on October 31, 1991. MTCs at heatup and cooldown were -29.4 pcm/°F and -30.2 pcm/°F, respectively.

      For both tests, the temperature changes were small, less than 2°F. These endpoint-dependent measurements would be obtained with greater precision with larger temperature changes, of the order of 4°F, which is common practice. This observation was discussed with plant personnel.

      No violations or deviations were identified.

6. Followup of Previous Open Items (92701)

   (Closed) UNR 50-327 and 50-328/90-29-03: Further review of the primary side heat balance required before application, as in Appendix D of SI-78.

SI-78 has been replaced in its entirety by 0-SI-OPS-092-078.0 (Revision 2), Power Range Neutron Flux Channel Calibration by Heat Balance Comparison. This procedure does not provide for calibration of PRNIs by primary side heat balance. Hence, this concern, raised by the observation of hot-leg streaming effects and the associated difficulty in measuring an average hot-leg temperature, is resolved.

7. Exit Interview

The inspection scope and findings were summarized on January 10, 1992, with those persons indicated in paragraph 1 above. The inspector described the areas inspected and discussed in detail the inspector followup items listed below. Dissenting comments were not received from the licensee. Proprietary information was reviewed in the course of the inspection, but is not contained in this report.

IFI 50-327 and 50-328/92-01-01: The licensee is considering changes in the use of the alternate dilute mode to prevent over-dilution of the VCT (paragraph 2.b).

IFI 50-327 and 50-328/92-01-02: The acceptance criteria for control rod worth measurements will be reviewed for consistency with assumptions made in SDM analysis (paragraph 2.f).

8. Acronyms and Initialisms Used in This Report

ANS	American Nuclear Society
ANSI	American National Standards Institute
ARO	All Rods Out
BOL	Beginning of (fuel cycle) Life
CB	Boron Concentration
COLR	Core Operating Limits Report
DMM	Digital Multi-Meter
DP	Differential Pressure
EAGLE 21	A digital system for measuring and processing RTD output.
HZP	Hot Zero Power
ICRR	Inverse Countrate Ratio
IRNI	Intermediate Range Nuclear Instrument
ITC	Isothermal Temperature Coefficient
Mohm	Mega-ohm
MTC	Moderator Temperature Coefficient
NRR	Office of Nuclear Reactor Regulation
OPdT	Overpower Differential Temperature
Pcm	Percent Millirho, a unit of reactivity
PDIL	Power Dependent (control rod) Insertion Limit
PRA	Probabilistic Risk Assessment
PRNI	Power Range Nuclear Instrument
RCS	Reactor Coolant System
RTD	Resistance Temperature Device
RTP	Rated Thermal Power
SDM	Shutdown Margin

TS	Technical Specifications
TVA	Tennessee Valley Authority
UNR	Un Resolved Item
VCT	Volume Control Tank