SEQUOYAH NUCLEAR PLANT

Four Year Simulator Test Report

for Period Ending

March 21, 1999

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I. INTRODUCTION

The submittal date of the initial certification of the Sequoyah simulator was March 21, 1991. The simulator certification process determines compliance on a four year interval with the requirements of ANSI-3.5-1985, Nuclear Power Plant Simulators for Use in Operator Training. This report outlines the test methods used, identifies any uncorrected test deficiencies, and includes a schedule for their correction. This report must be submitted to the NRC on the anniversary of certification, in accordance with 10 CFR 55.45 (b) (5) (ii).

Simulator test schedules were provided in the four year report submitted in March 1995. The tests were completed as outlined in those schedules.

II. GENERAL DISCUSSION

The Sequoyah simulator was first used for operator training in 1979 -- the original vendor was S3 Technologies (Singer-Link). It is used to license operators on both Unit 1 and Unit 2, with Sequoyah Unit 1 as the design reference plant. Since the last report submitted in 1995, the simulator has been used nearly continuously for various training needs at Sequoyah. During this testing period it has been maintained as required. Modifications and tuning adjustments were completed on a regular basis to maintain simulator configuration as close as practical to Unit 1.

The Sequoyah simulator uses a computer system that last received an upgrade in 1995. The main simulator computer uses two Mercury i860 processors. The simulator I/O system was completely upgraded and replaced in a phased-approach over a five year period, with the project completing in 1998. Sun workstations provide the instructor station and model development interface. One major plant modification that was installed two years ago involved the replacement and modification of simulator furniture, computer monitors, computers, computer peripherals, and various printers in the Main Control Room horseshoe area to replicate the new Integrated Computer System.

During the past four years, work on the simulator included tuning models to match plant data, improving model performance, installing new training malfunctions, and implementing plant design changes. Problem Reports (PRs) and Design Change Requests (DCRs) were processed during this period, as follows:

Work Item	Number at Start*	Opened	Closed	Number at End*
Problem Reports	60	690	730	20
Design Change Requests	36	136	150	22

*NOTE: Each of the PRs and DCRs [illegible]ng at the start were completed by the end of the four year test period. The N[illegible]nber at End were documented March 1, 1999.

III. DESCRIPTION OF COMPLETED TESTS

This section summarizes the tests completed on the simulator over the past four years. Detailed test documentation is maintained by the Simulator Services group at the Sequoyah Training Center for review, in accordance with the requirements of 10 CFR 55.45 (b) (5) (iii). The uncorrected deficiencies are described in Section V, Uncorrected Test Performance Deficiencies and Correction Schedule.

A. Steady State Tests

Steady State Tests were performed annually. Plant critical and non-critical test parameters (refer to Table 1) were compared to the equivalent simulator values at each of three power levels. The error was calculated based on ± 2% of span for critical and ± 10% of span for non-critical parameters. A total of six deficiencies were captured in PRs or DCRs in the last four years: all of these were resolved.

TABLE 1

CRITICAL TEST PARAMETERS	NON-CRITICAL TEST PARAMETERS
Generator Gross MW	Generator Voltage
Reactor Thermal Power Calculated	Generator MVARs
Intermediate Range Channel	RCS Loop Average Temperatures
Power Range Channels	RCS Loop Over-Power Delta-Temperatures
Control Bank D Rod Position	RCS Loop Over-Temp Delta-Temperatures
RCS Loop Flows	Reactor Vessel Wide Range Level
RCS Hot Leg Loop Wide Range Temperatures	Reactor Vessel Narrow Range Level
RCS Cold Leg Loop Wide Range Temperatures	Reactor Vessel Plenum Level
RCS Auctioneered High Average Temperature	Pressurizer Relief Tank Level
RCS Reference Temperature	Pressurizer Relief Tank Press
RCS Loop Delta-Temperatures	Pressurizer Relief Tank Temp
Charging Pump Discharge Header Pressure	Refueling Water Storage Tank Level
Pressurizer Level	Accumulator Tank Levels
Pressurizer Pressure	Accumulator Tank Pressures
Containment Pressure	Charging Header Flow
Steam Generator Narrow Range Levels	Letdown Flow
Steam Generator Feed Flows	Steam Generator Wide Range Levels
Steam Generator Steam Flows	Feedwater Header Pressure
Steam Generator Steam Pressures	125VDC Vital Battery Board Voltages
Steam Line Header Pressure	250VDC Battery Board Voltage
#1 Feedwater Heaters Outlet Header Pressure	480V Shutdown Board Voltages
	6.9 kV Shutdown Board Voltages
	500 kV Bus Voltage
	CCS Heat Exchanger Inlet Pressure
	ERCW Supply Header Flows

B. Drift Tests

Drift Tests were performed annually. The simulator was reset to 100 percent power and data was collected for an hour for each critical parameter at a rate of two samples per second. Plots were made with this data to check for stability. A parameter would fail the test if it drifted beyond ± 2% of the initial value. No test deficiencies occurred.

C. Transient Tests

The 10 Transient Tests were performed annually (refer to Table 2). Data was collected for required parameters at a rate of two samples per second. Each year the test results were plotted and compared with responses from the prior year and with initial certification data. Additionally, a Transient Review Committee consisting of engineers, instructors and operators evaluated each Transient Test in January 1999 for an independent evaluation. Each of the 10 transients were given this additional review. A total of five deficiencies were captured in PRs or DCRs in the last four years: two PRs remain to be completed.

TABLE 2

TRANSIENT TEST LIST
1. Manual Reactor Trip
2. Simultaneous Trip of All FW Pumps
3. Simultaneous Closure of All MSIVs
4. Simultaneous Trip of All RCPs
5. Trip of Any Single RCP
6. Main Turbine Trip at Max Power that Does Not Result in Reactor Trip (<P-9)
7. Maximum Power Ramp (100% To 75% Then Back Up To 100%)
8. Maximum Size Reactor Coolant System Rupture Combined with Loss of All Offsite Power
9. Maximum Size Un-Isolable Main Steam Line Rupture
10. Slow Primary System Depressurization to Saturated Condition Using Pressurizer Relief or Safety Valve Stuck Open with No High Head Injection

D. Procedure Tests

To distribute the work load between each testing year, approximately 25 percent of the procedure tests were performed each year. At the completion of the four year test cycle, each of the procedure tests had been completed. Table 3 provides a summary of the tests performed. Each test used the latest revision of Unit 1 controlled procedures. A total of 36 deficiencies were captured in PRs or DCRs in the last four years: three DCRs remain to be completed.

TABLE 3

PROCEDURE TEST LIST	
Annual Test Period Ending	Procedure Description
1996	General Operating Procedures: Plant Start Up from Cold Iron to 100 Percent Power
1997	General Operating Procedures: Plant Shutdown from 100 Percent Power to Cold Iron
1998	Emergency Operating Procedures (includes Functional Restoration Guidelines and Emergency Contingency Actions)
1999	Abnormal Operating Procedures and Emergency Abnormal Procedures

NOTE: The schedule above shows which set of procedures were performed during a particular test year. Detailed procedure numbers are not used because they may change. The test period ends on March 21 of each test year.

E. Malfunction Tests

To distribute work load in each testing year, approximately 25 percent of required malfunctions were tested annually (refer to Table 4). At the completion of the four year test cycle, each of the required malfunctions had been tested. After inserting each malfunction, simulator response was compared to the Malfunction Cause and Effects document, to plant procedures, and to available actual plant data. Additionally, a check was made to ensure that an appropriate Initial Condition existed, that the simulator could be operated to a steady state condition, that operators would take the same actions in the reference plant, that the variable rate features (if any) could be manipulated, and whether or not the malfunction could be removed. A total of 37 deficiencies were captured in PRs or DCRs in the last four years: all of these were resolved.

TABLE 4

MALFUNCTION TEST LIST				
Annual Test Period Ending	Item Number	Malfunction Number	Malfunction Description	ANSI-3.5 Section
1996	1	CV09	VCT Level Transmitter Fails High	3.1.2(18)
	2	TH05	Steam Generator Tube Leak	3.1.2(1a)
	3	CV04	Letdown Line Break Inside Auxiliary Building	3.1.2(1b)
	4	TH03	Small Break Loss of Coolant Accident	3.1.2(1c)
	5	TH04	Failure of Pressurizer Safety Valve	3.1.2(1d)
	6	RD13	Stuck Rod	3.1.2(12)
	7	IA02	Loss of Non-Essential Control Air	3.1.2(2)
	8	ED01	Total Loss of Offsite Power	3.1.2(3)
	9	ED06	Loss of 6.9kV Shutdown Board	3.1.2(3)
	10	ED08	Loss of 480 VAC Shutdown Board	3.1.2(3)

Note: The test period ends on March 21 of each test year.

TABLE 4 (Continued)

MALFUNCTION TEST LIST				
Annual Test Period Ending	Item Number	Malfunction Number	Malfunction Description	ANSI-3.5 Section
1997	1	ED15	Loss of 250 VDC Battery Board	3.1.2(3)
	2	RC01	Reactor Coolant Pump Locked Rotor	3.1.2(4)
	3	RD05	Rod Misalignment	3.1.2(12)
	4	RW02	Raw Cooling Water Pump Trip	3.1.2(6)
	5	RW07	Loss of Cooling to Main Feed Pump Oil Coolers	3.1.2(6)
	6	RH04	Residual Heat Removal Loop Suction Line Blockage	3.1.2(7)
	7	RP01	Reactor Trip Signal Failure	3.1.2(24)
	8	CC04	Component Cooling Pipe Break Inside Containment	3.1.2(8)
	9	CN02	Condensate Booster Pump Trip	3.1.2(9)
	10	MS01	Main Steam Line Break Inside Containment	3.1.2(20)
	11	FW05	Loss of All Feedwater: Trip of Turbine MFWP	3.1.2(10)
		FW07	Loss of All Feedwater: Trip of AFWP	3.1.2(10)
1998	1	TH01	Hot Leg Loss of Coolant Accident	3.1.2(1c)
	2	TU02	Main Turbine High Vibration	3.1.2(15)
	3	EG01	Main Generator Trip	3.1.2(16)
	4	ED10	Loss of 120 VAC Inverter	3.1.2(3,11)
	5	RX18	Failure of T-average Control Signal	3.1.2(17)
	6	RX07	Pressurizer Pressure Transmitter Failed High	3.1.2(18)
	7	RH01	Residual Heat Removal Pump Trip	3.1.2(7)
	8	RP05	False Auto Reactor Trip Signal	3.1.2(19)
	9	MS02	Main Steam Line Break Outside Containment	3.1.2(20)
	10	FW23	Main Feedwater Line Break Inside Containment	3.1.2(20)
	11	RD07	Dropped Rod	3.1.2(12)
1999	1	ED12	Loss of 125 VDC Vital Bus	3.1.2(3)
	2	NI07	Power Range Channel Output Signal Failure	3.1.2(21)
	3	HD12	#1 Feedwater Heater Level Control Failed Low	3.1.2(22)
	4	CN09	Loss of Vacuum	3.1.2(5)
	5	CV15	Charging Flow Control Problem: Pressurizer Level Swing	3.1.2(22)
	6	RP02	Auto Safety Injection Initiation Signal Failure	3.1.2(23)
	7	IA03	Loss of Essential Control Air	3.1.2(2)
	8	RD08	Rods Fail to Move on Demand	3.1.2(13)
	9	THR02	Fuel Cladding Failure	3.1.2(14)
	10	FW20	Main Feedwater Line Break Outside Containment	3.1.2(20)
	11	NI04	Intermediate Range Channel Failure	3.1.2(21)
	12	CV01	Charging Pumps Trip	3.1.2(18)
	13	CV16	Failure of Letdown Relief Valve	3.1.2(22)
	14	RC05	Failure of Pressurizer Power Operated Relief Valve	3.1.2(1d)
	15	EG02	Loss of Emergency Diesel Generators	3.1.2(3)
	16	CN23	Loss of Condenser Level Control (Hotwell Dumpback)	3.1.2(5)
		CN29	Loss of Condenser Level Control (Hotwell Makeup)	3.1.2(5)

Note: The test period ends on March 21 of each test year.

F. Real Time Tests

Three types of Real Time Tests were performed annually:

1. Each Transient Test was checked by a stop watch against the computer run time clock.

2. The simulator uses a real time executive test, which runs continually and monitors the execution of all simulation models. If a portion of a calculation does not finish in time, the simulator will automatically halt. A check confirmed that the simulator did not halt during any Transient Test.

3. For testing purposes, the simulator was forced to slip a timing frame to ensure that the simulator would halt.

No Real Time Test deficiencies were found.

G. Simulator Fidelity

As modifications are being initiated in the plant, design change packages are reviewed by the simulator staff for applicability. Additionally, photographs are made of the plant Main Control Room panels for comparison with the simulator. Items that were identified as having training impact were incorporated into the simulator under the DCR process. Plant changes are required to be compiled at least annually, and appropriate simulator modifications are required to be made within the following year. The required modifications were implemented within these time limits.

H. Simulator Limitations

The Sequoyah simulator imposes four Limitations (refer to Table 6). It is possible to create events on the simulator which progress beyond plant design limits. To avoid negative training, which could result from simulator operation during such events, the occurrence of an event on the simulator that progresses beyond the plant design limits causes the simulator to automatically halt.

TABLE 5

LIMITATIONS LIST	
1.	Containment pressure exceeds the design limit (15psig).
2.	Fuel clad temperature exceeds the clad melt point (1533 degrees K).
3.	Turbine extraction lines flood (any FW Heater full of water, with water in extraction line).
4.	Turbine shaft seizes (bearing oil temperature >235 degrees F, and turbine speed <0.1 RPM).

I. Simulator Exceptions

Significant differences in simulator fidelity, other than those addressed by open PRs or DCRs, are tracked as Exception Reports (refer to Table 6 for the current list). Each have been evaluated to have no negative impact on training.

TABLE 6

OPEN EXCEPTION REPORT LIST		
Exception Number*	Open Date	Exception Description
2	3/4/91	The ceiling and lighting do not match the plant Main Control Room: the plant ceiling diffuser grid is suspended ~12 inches above the panels; normal plant lighting is AC fluorescent lighting above the diffuser grid; and, emergency plant DC lighting is either wall mounted or suspended below the diffuser grid. The simulator is in a two story room with recessed Mercury vapor lighting. The second floor walls are lined on two sides with floor-to-ceiling glass windows for viewing from the second floor, fitted with adjustable shades. The simulator can replicate neither the loss of AC lighting nor the use of emergency DC lighting.
3	3/4/91	Panel M-7 is not simulated. In the plant, this panel contains the preferred and instrument power distribution breakers and transfer switches (remote functions are available).
4	3/4/91	Panel M-8 is not fully simulated. The rod coil disconnect switches are simulated, but turbine supervisory power drawers are not.
6	3/4/91	Panels M-21 and M-22 are not simulated. Plant panels contain the annunciator logic and SSPS demultiplexer cabinets.
8	3/4/95	Panel M-28A is not fully simulated for Unit 2 EGTS controls, and it is not located the same distance from the horseshoe as in the plant.
9	3/4/91	Electrical Control Board (switchyard control) is only partially simulated -- the side to side spacing of breaker bays has been collapsed to preserve floor space.
12	7/21/92	Back panel M-31 is partially simulated -- a radiation monitor controller and two recorders are not simulated due to little use and high cost to replicate.
14	11/10/94	The simulator cannot be used for training on Unit 2 procedures.

*Note: For brevity, the six (6) closed Exceptions are not listed.

IV. Status of Uncorrected Test Performance Deficiencies Reported in 1995

Five open test deficiencies were documented in the four year report submitted in 1995. All five items were completed prior to their scheduled date.

V. Uncorrected Test Performance Deficiencies and Correction Schedule

Five open test deficiencies exist at the start of the next four year testing period. They are planned for correction as shown in Table 7.

TABLE 7

SCHEDULE FOR THE CORRECTION OF TEST DEFICIENCIES			
Test	Deficiency	Description of Deficiency	Scheduled Date
Transient	PR-2661	RCS loop delta-temperature is too low during Natural Circulation.	7/1/99
	PR-2802	S/G Safety valves incorrectly open on a loss of steam dumps.	7/1/99
Procedure	DCR-750	Add the Unit 2 Yokogowa EGTS controllers to panel M-28.	7/1/99
	DCR-790	Add remote functions for stripping individual breaker loads from vital battery boards.	5/28/99
	DCR-815	Simulate Unit 2 Emergency Shutdown buses supplying Unit 1 6.9 kV Shutdown boards.	5/28/99

VI. DESCRIPTION OF TEST DIFFERENCES FOR THE NEXT FOUR YEAR TEST PERIOD

During the next four year test period, each simulator test is planned to be performed in a manner similar to that of the previous period; no changes are anticipated in critical and non-critical test parameters.

VII. SCHEDULE FOR TESTING DURING THE NEXT FOUR YEAR TEST PERIOD

Table 8 lists planned test starting dates for the next simulator reporting cycle. The next anniversary of the Four Year Simulator Test Report is March 21, 2003.

TABLE 8

SCHEDULE FOR TESTING DURING THE NEXT FOUR YEAR TEST PERIOD					
Test Type		Planned Start Year 1 (Test Period Ending 3/21/2000)	Planned Start Year 2 (Test Period Ending 3/21/2001)	Planned Start Year 3 (Test Period Ending 3/21/2002)	Planned Start Year 4 (Test Period Ending 3/21/2003)
Procedure *	(25% annually)	9/1/1999	9/1/2000	9/1/2001	9/1/2002
Transient/Real Time	(100% annually)	10/1/1999	10/1/2000	10/1/2001	10/1/2002
Malfunction **	(25% annually)	11/1/1999	11/1/2000	11/1/2001	11/1/2002
Steady State	(100% annually)	12/1/1999	12/1/2000	12/1/2001	12/1/2002

Note: * Procedure tests will be conducted each test year in the pattern shown in Table 3.
** Malfunction tests will be conducted each test year in the pattern shown in Table 4.