NATURAL CIRCULATION DEMONSTRATION COMPARISON
BETWEEN THE V. C. SUMMER STATION
AND THE
SCE&G TRAINING SIMULATOR

NATURAL CIRCULATION DEMONSTRATION COMPARISON

TABLE OF CONTENTS

NATURAL CIRCULATION DEMONSTRATION COMPARISON

LIST OF TABLES

NATURAL CIRCULATION DEMONSTRATION COMPARISON

LIST OF FIGURES

1.0 INTRODUCTION

This report has been prepared to meet the commitment of Condition (23)b. of the Virgil C. Summer Station, Unit No. 1 Facility Operating License. Specifically, Condition (23)b., Special Low Power Testing and Training, requires that:

> "Within twelve months following completion of the startup test program, SCE&G shall provide a report describing the results of a comparison of the actual plant data taken during the natural circulation test program to the simulator responses described in the SCE&G letter, T. C. Nichols, Jr. to H. R. Denton dated March 31, 1982."

This report provides that comparison.

2.0 OBJECTIVE

The objective of this report is to compare the results of the actual data from the V. C. Summer Station Natural Circulation Demonstration Program to the corresponding data from the Factory Acceptance Tests of the V. C. Summer Training Simulator. The same acceptance criteria was used in both cases. The program includes the following tests.

1. Natural Circulation Demonstration
2. Pressurizer Spray and Heater Capability
3. Core Cooling with a Simulated Loss of Onsite and Offsite AC Power
4. Station Blackout

The simulator tests developed for the Natural Circulation and the Core Cooling tests were adapted directly from the corresponding plant test procedures. The Pressurizer Spray and Heater Capability Test was adapted from the applicable portions of the plant test. The Station Blackout test comparison is based upon a repeat of the actual plant test performed on the simulator following delivery to SCE&G. This was necessitated since the Station Blackout test performed during the simulator Factory Acceptance Test was done from a 100% Steady State Full Power, BOL, Xenon Equilibrium condition. The Station Blackout test at the plant was performed with the reactor at 11% of full power. It was decided to perform an exact repeat of the plant test to obtain a more direct comparison. The relationship of these tests is shown on the following page.

PLANT TEST	SIMULATOR TEST
ZPT-9.1	14.4.6.13
HST-7	14.4.6.3
ZPT-9.2	14.4.6.14
POT-11	POT-11

Those critical parameters based upon engineering, operations and training considerations are the basis for comparisons made in this report.

3.0 COMPARISON OF NATURAL CIRCULATION DEMONSTRATION

3.1 The Natural Circulation Demonstration test was performed on the V. C. Summer simulator as part of the normal Factory Acceptance Test. The simulator test procedure was directly adapted from the plant procedure (ZPT-9.1). The simulator and plant tests were both performed with reactor power at 3 $\pm$ 1/2 percent. All operational steps were the same and were performed in the same sequence. The simulator initially indicated less than desired ΔT. Subsequent simulator tuning resulted in extremely close correlation of plant and simulator data. Tables 1 and 2 indicate the actual readings of the initial and final conditions obtained from the plant and simulator instrumentation. Table 3 provides a summary of initial and final temperatures and reactor power for the plant and simulator. Any difference in pressures and levels are due to inherent differences in operator control of emergency feedwater. Figure 1, calculated from the V. C. Summer FSAR, indicates the resultant ΔT for the plant and the simulator. The comparison of actual plant and simulator data is extremely close. Operator training for natural circulation operations can be accomplished using the simulator.

3.2 Acceptance Criteria

3.2.1 The highest loop ΔT is less than the assumed value in the safety analysis for the power level at which the test was conducted.

3.2.2 Natural Circulation has been demonstrated.

TABLE 1

NATURAL CIRCULATION COMPARISON

INITIAL CONDITIONS

Parameter	Loop	Source	Plant Value	Simulator Value
Wide Range T_{Hot} (°F)	A	TR-413	555	556
	B	TR-413	555	556
	C	TR-413	555	556
Wide Range T_{Cold} (°F)	A	TR-410	560	556
	B	TR-410	560	556
	C	TR-410	550	556
RCS Loop Flow (%)	A	FI-414	105	102
	B	FI-424	107	102
	C	FI-434	110	102
Steam Generator Level (%)	A	LI-474	31	36
	B	LI-484	37	38
	C	LI-494	37	38
Steam Generator Pressure (Psig)	A	PI-474	1060	1100
	B	PI-484	1060	1100
	C	PI-494	1080	1100
Steam Flow (MPPH)	A	FI-474	.30	.50
	B	FI-484	.25	.50
	C	FI-494	.10	.50
Emergency Feed Flow (GPM)	A	FI-3561	220	230
	B	FI-3571	170	235
	C	FI-3581	140	230
Pressurizer Level (%)	N/A	LI-459	26	28
Pressurizer Pressure (Psig)	N/A	PI-444	2220	2225
	N/A	PI-455	2220	2225

TABLE 2

NATURAL CIRCULATION COMPARISON

FINAL CONDITIONS

Parameter	Loop	Source	Plant Value	Simulator Value
Wide Range T_{Hot} (°F)	A	TR-413	587	590
	B	TR-413	595	590
	C	TR-413	587	590
Wide Range T_{Cold} (°F)	A	TR-410	559	557
	B	TR-410	559	557
	C	TR-410	549	557
RCS Loop Flow (%)	A	FI-414	<10	10
	B	FI-424	0	0
	C	FI-434	0	5
Steam Generator Level (%)	A	LI-474	36	34
	B	LI-484	36	39
	C	LI-494	38	40
Steam Generator Pressure (Psig)	A	PI-474	1060	1100
	B	PI-484	1060	1100
	C	PI-494	1080	1100
Steam Flow (MPPH)	A	FI-474	.10	.05
	B	FI-484	.25	.05
	C	FI-494	.10	.05
Emergency Feed Flow (GPM)	A	FI-3561	120	240
	B	FI-3571	150	235
	C	FI-3581	130	235
Pressurizer Level (%)	N/A	LI-459	34	39
Pressurizer Pressure (Psig)	N/A	PI-444	2260	2240
	N/A	PI-455	2255	2240

TABLE 3

NATURAL CIRCULATION SUMMARY DATA

INITIAL CONDITIONS

	Plant				Simulator		
	WR Test Recorder Data			Corrected(1)	WR Data		
Loop	T_{Hot}	T_{Cold}	ΔT	ΔT	T_{Hot}	T_{Cold}	ΔT
A	560	560	0	2.087	556	556	0
B	560	560	0	1.576	556	556	0
C	553	553	0	0.0(2)	556	556	0

Average Plant T = 1.83°F | Average Simulator T = 0°F

Reactor Power = 2.86% | Reactor Power = 2.95%

FINAL CONDITIONS

	Plant				Simulator		
	WR Test Recorder Data			Corrected(1)	WR Data		
Loop	T_{Hot}	T_{Cold}	ΔT	ΔT	T_{Hot}	T_{Cold}	ΔT
A	595	560	35	37.1	590	557	33
B	588	567	21	22.6	590	557	33
C	588	546	42	42.0(2)	590	557	33

Average Plant T = 33.9°F | Average Simulator T = 33.0°F

Reactor Power + 2.86% | Reactor Power = 3.00%

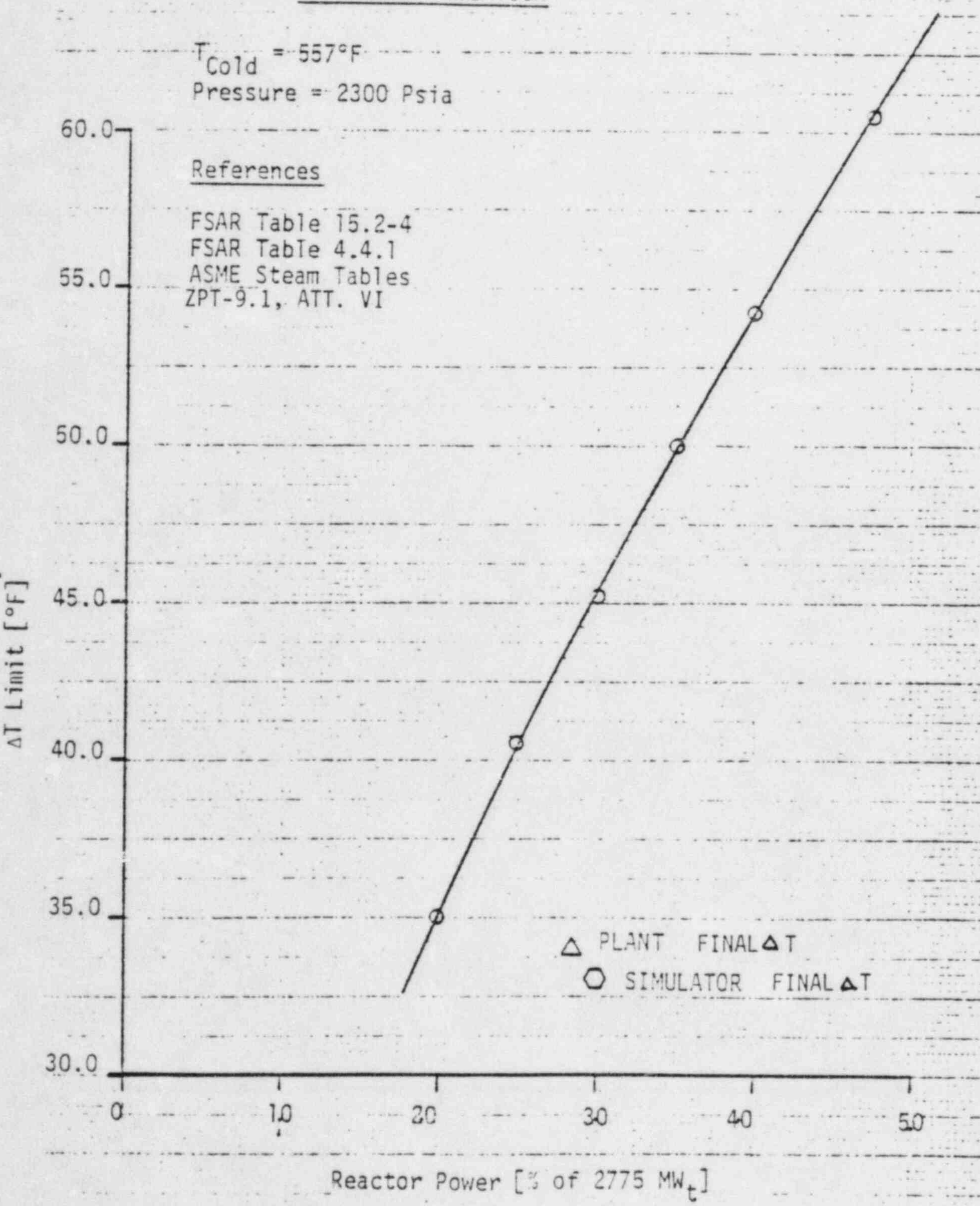
(1) This wide range ΔT was corrected for the initial condition offset between wide range and narrow range ΔT.

(2) The narrow range ΔT instrument out of service.

FIGURE 1

ΔT LIMIT VS. REACTOR POWER

NATURAL CIRCULATION



4.0 COMPARISON PRESSURIZER SPRAY AND HEATER CAPABILITY

4.1 The pressurizer Spray and Heater Capability test was performed on the V. C. Summer simulator as part of the normal Factory Acceptance Test. The simulator test procedure was adapted from Sections 6.6 and 6.7 of the plant procedure (HST-7). The simulator and plant tests were both performed from a Hot Standby (Mode 3) condition. All operational steps were the same and were performed in the same sequence. The plant and simulator response to opening of both pressurizer spray vavles is consistent with the NSSS expected behavior except for the first 15 seconds. During the conduct of the spray test for the plant an elevated pressure, above the upper limit, was indicated for the first 15 seconds. The simulator exhibited this identical anomaly. Evaluation by Westinghouse (Reference 7.11) concluded that, "changes in the pressure response of this magnitude are not considered significant". If should be noted that this anomaly has been substantiated and is reflected in the results of the simulator test as indicated on Figure 2. The remaining subsequent response of both the plant and simulator closely parallel the expected nominal response.

The response of the plant and simulator to the activation of all pressurizer heaters are within the expected limits. The response of the simulator more closely parellels the expected response, since the simulator was based on design data.

The overall response of the simulator pressurizer spray and heater capability test confirms and reinforces that which is predicted and expected by the operator trainee. Figures 2 and 3 indicate the response of both the plant and simulator tests.

4.2 Acceptance Criteria

4.2.1 The observed pressurizer pressure response to full pressurizer spray activation falls between the limits shown on Figure 2.

4.2.2 The observed pressurizer pressure response to full pressurizer heater activation falls between the limits shown on Figure 3.

FIGURE 2

RESPONSE TO OPENING OF BOTH PRESSURIZER SPRAY VALVES

PLANT VERSUS SIMULATOR

V. C. SUMMER

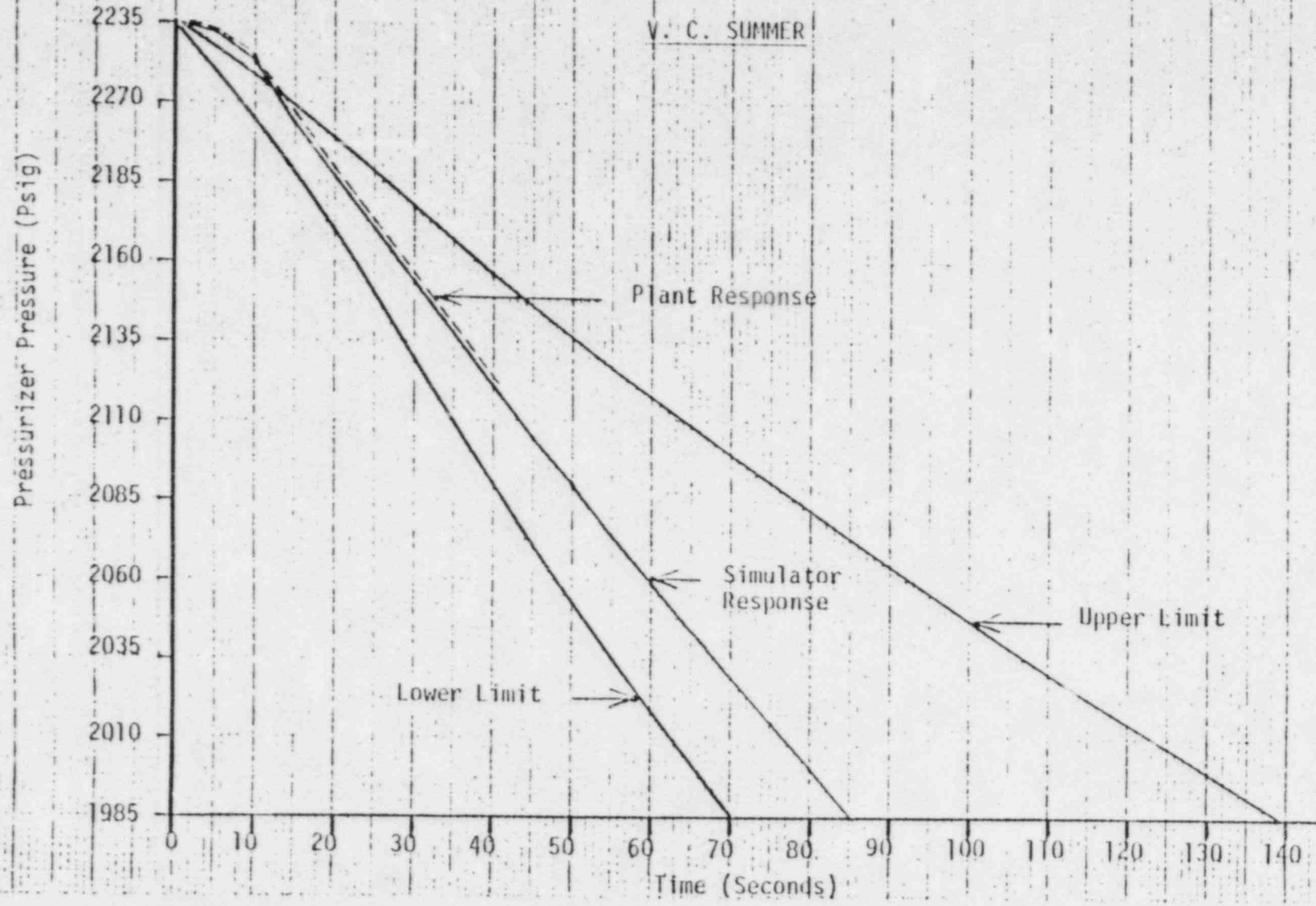
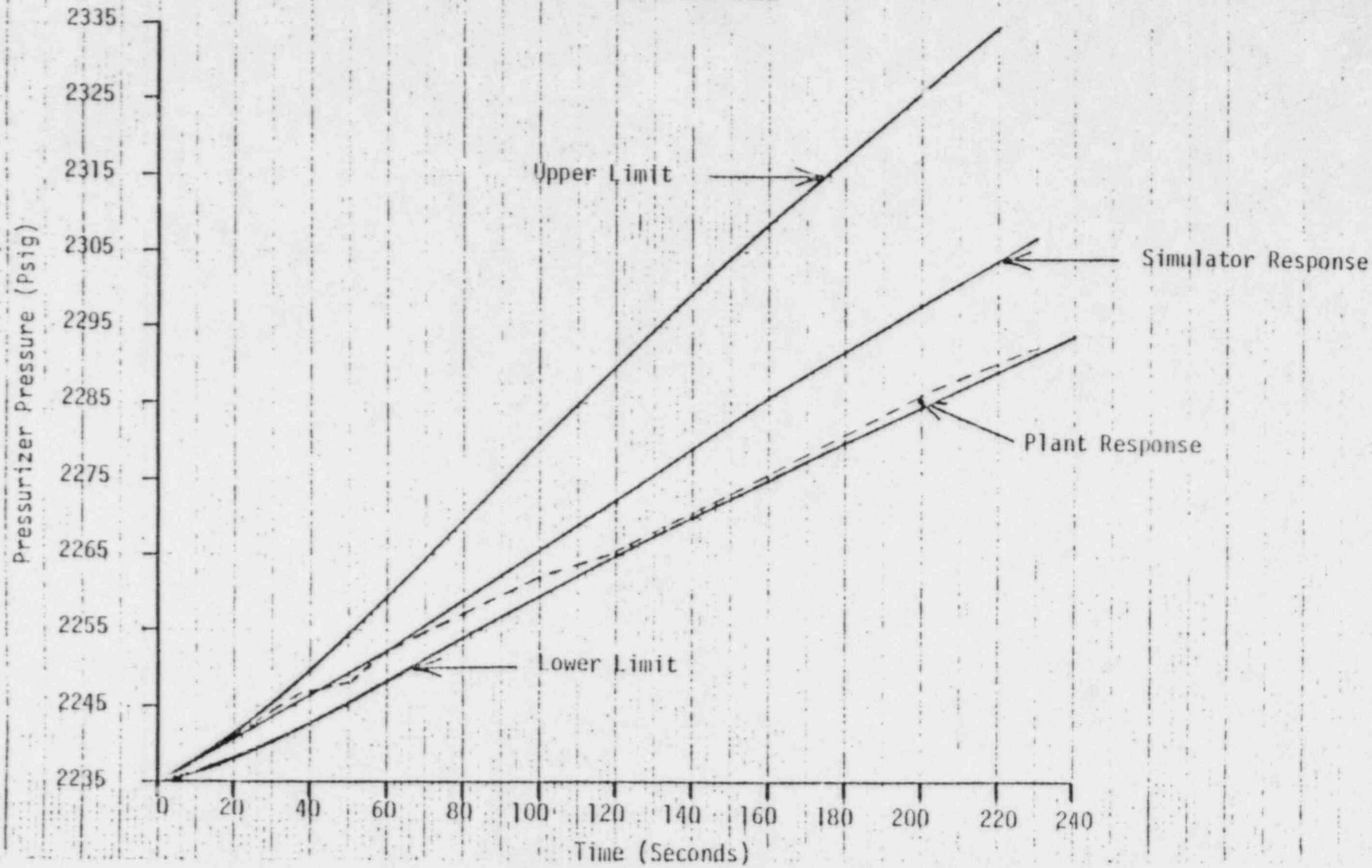


FIGURE 3

RESPONSE TO ACTIVATION OF ALL PRESSURIZER HEATER

PLANT VERSUS ACTUAL

V. C. SUMMER



5.0 COMPARISON OF CORE COOLING WITH A SIMULATED LOSS OF ONSITE AND OFFSITE AC POWER

5.1 The Core Cooling with a Simulated Loss of Onsite and Offsite AC Power test was performed on the V. C. Summer simulator as part of the normal Factory Acceptance Test. The simulator test procedure was directly adapted from the plant procedure (ZPT-9.2). The simulator and plant tests were both performed from a Hot Shutdown condition with T_{avg} being maintained at approximately 557°F. The purpose of the tests was to demonstrate the capability of removing decay heat utilizing manual control of the Turbine Driven Emergency Feedwater Pump. The ability to maintain Steam Generator Levels and Pressure, Figure 4, and Pressurizer Level and Pressue, Figure 5, was also demonstrated. The results of both tests reflect the operators ability to maintain these parameters. Any differences in pressures and levels are due to inherent differences in operator control of emergency feedwater flow. However, in both cases it can be seen that complete and consistent control was achieved at approximately 35 minutes into the evolutions. Figure 6 indicated the ability to maintain and/or decrease T_{avg} using only the Turbine Driven Emergency Feedwater Pump. Operator training can successfully be accomplished using the simulator.

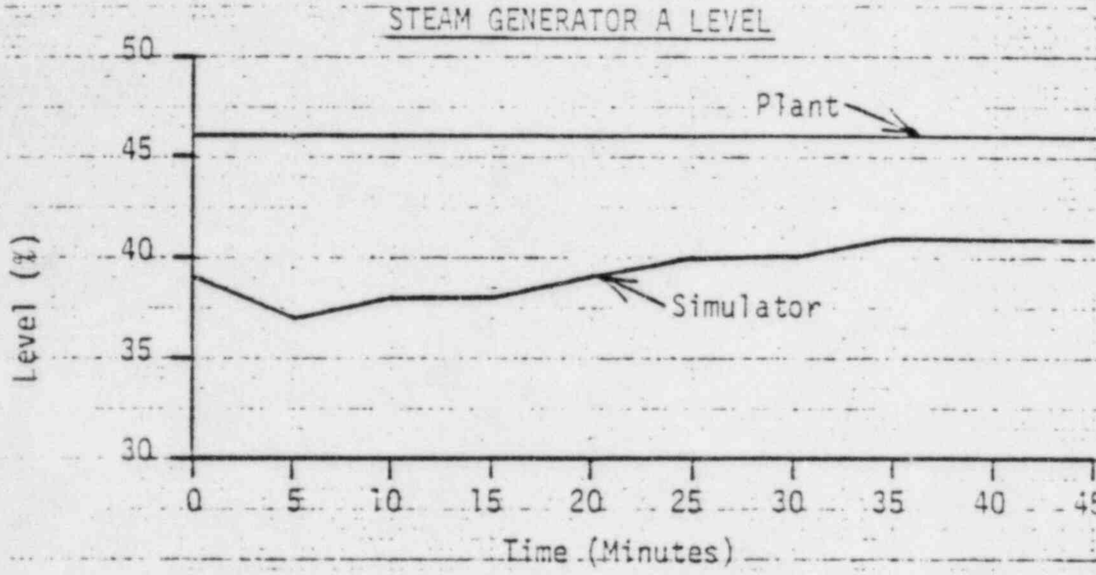
5.2 Acceptance Criteria

5.2.1 Core cooling can be maintained while maintaining steam generator levels with the Turbine Driven Emergency Feedwater Pumps (simulated loss of onsite and offsite power).

FIGURE 4

TYPICAL STEAM GENERATOR RESPONSE TO A SIMULATED LOSS OF ONSITE AND OFFSITE AC POWER

V. C. SUMMER



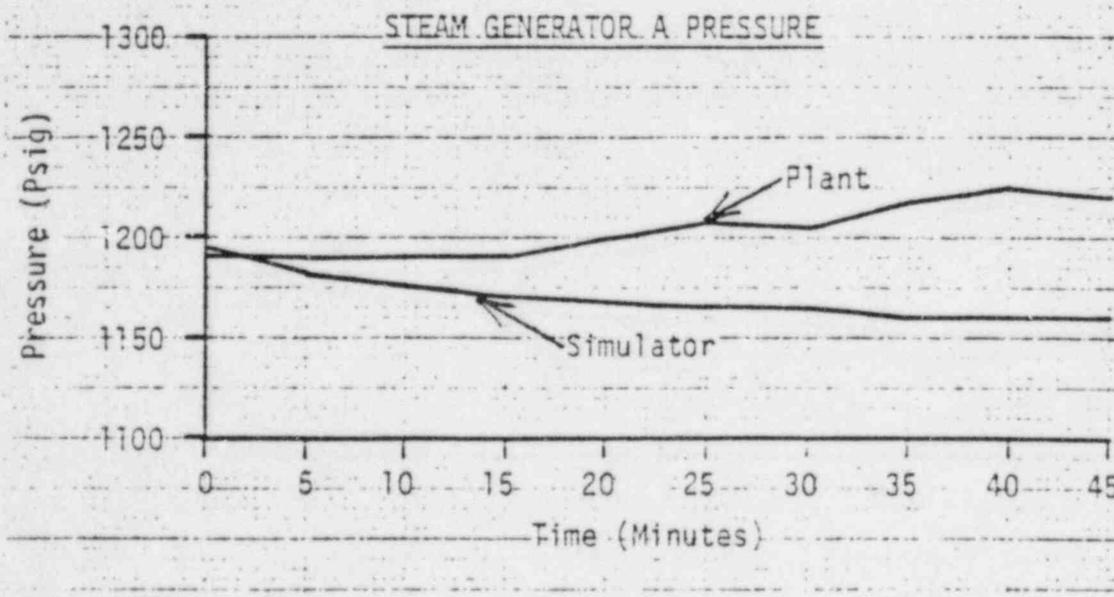


FIGURE 5

PRESSURIZER RESPONSE TO A SIMULATED
LOSS OF ONSITE AND OFFSITE
AC POWER

V. C. SUMMER

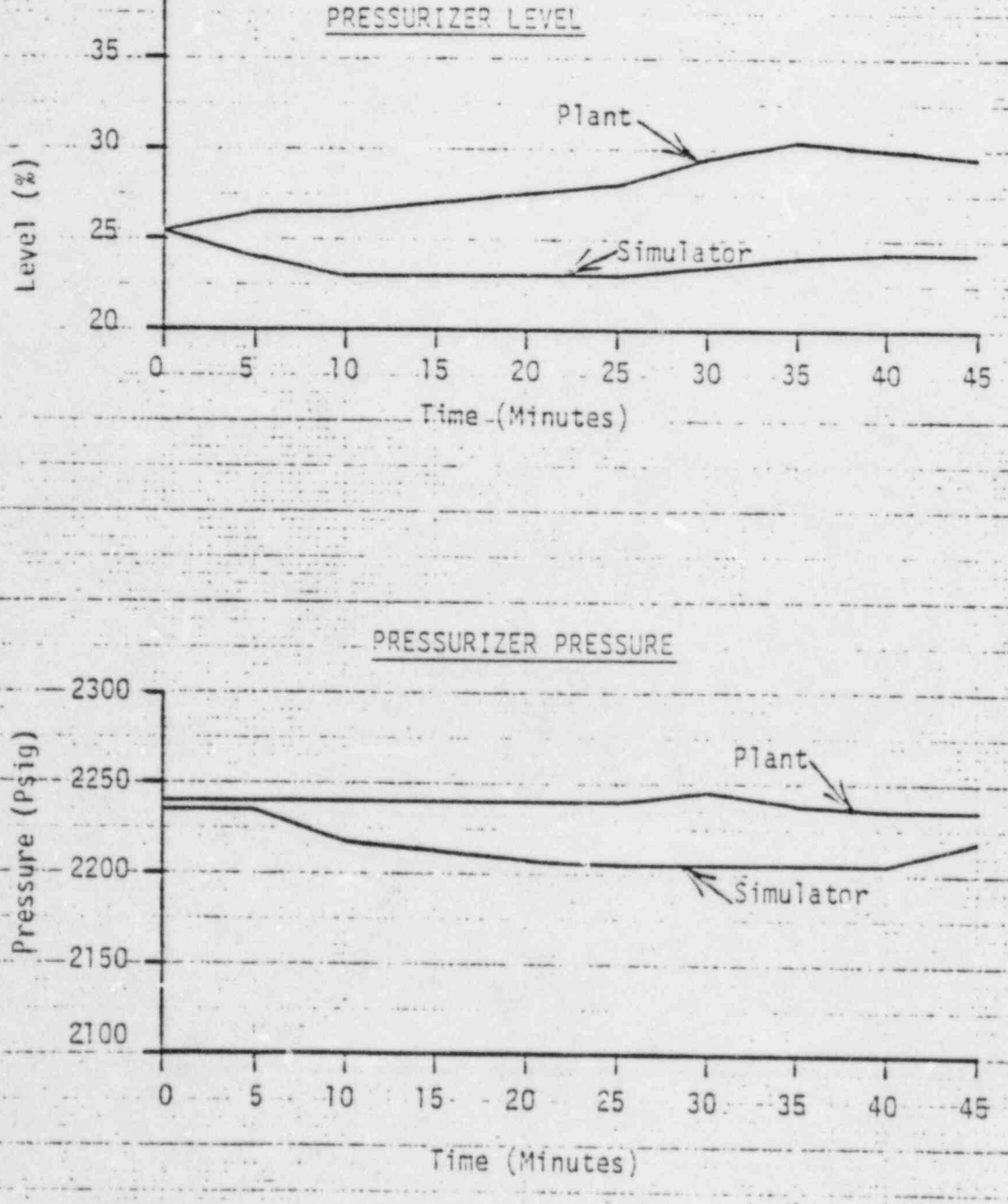
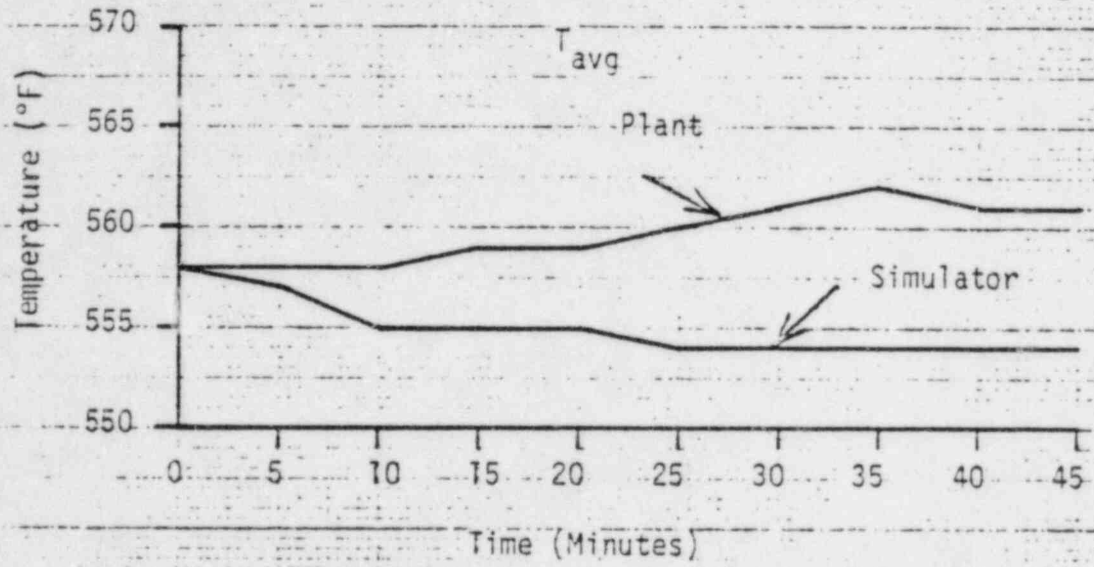


FIGURE 6

T_{avg} RESPONSE TO A SIMULATED LOSS OF ONSITE AND OFFSITE AC POWER

V. C. SUMMER



6.0 COMPARISON OF STATION ELECTRICAL BLACKOUT

6.1 The Station Electrical Blackout Test was performed on the V. C. Summer simulator after delivery to the SCE&G Nuclear Training Center. The simulator test utilized the actual plant Station Electrical Blackout test procedure (POT-11). This was necessitated because the Station Blackout test procedure performed during the simulator Factory Acceptance Test was performed from a 100% Full Power condition while the plant test was performed at 11% of full power. Repeating the test on the simulator at 11% of full power provides a better comparison of initial and final conditions, Tables 4 and 5, between the plant and the simulator. The results of this test demonstrate that the necessary equipment, controls and indications are available to remove decay heat using only emergency power supplies. In accordance with the test procedure, Hot Standby conditions were maintained on the simulator and the plant when the test was performed. The plant test indicated a RCS cooldown, and resultant increased ΔT and RCS flow rates. Any difference in pressure and levels are due to inherent differences in operator control of Emergency Feedwater Flow. The overall results of this comparison indicate that operator training for the Station Electrical Blackout scenario can be successfully accomplished using the simulator.

6.2 Acceptance Criteria

6.2.1 The Hot Standby condition is acheived and maintained for at least thirty minutes using only emergency onsite power sources.

TABLE 4

STATION ELECTRICAL BLACKOUT

INITIAL CONDITIONS

Parameter	Source	Plant Value	Simulator Value
Pressurizer Pressure (Psig)	PR-444	2240	2250
Pressurizer Level (%)	LR-459	28	31
Turbine First Stage Pressure (Psia)	PI-446	60	75
T_{avg} (°F)	TR-408	564	564
Loop A ΔT (%)	TI-411B	13	12
Loop B ΔT (%)	TI-421B	14	14
Loop C ΔT (%)	TI-431B	16	11
Power Level (%)	NR-45	11	11
RCS Flow Loop A (%)	FI-415	105	102
RCS Flow Loop B (%)	FI-425	108	103
RCS Flow Loop C (%)	FI-435	112	102
Main Steam Header Pressure (Psig)	PI-464C	1060	1110
S/G A Steam Pressure (Psig)	PR-475	1090	1120
S/G B Steam Pressure (Psig)	PR-475	1090	1100
S/G C Steam Pressure (Psig)	PR-475	1090	1100
Generator Load (MW_e)	EHC	100	90
S/G A Level (%)	LR-478	55	40
S/G B Level (%)	LR-488	40	39
S/G C Level (%)	LR-498	40	38
S/G A Feedwater Flow (MPPH)	FR-478	.4	.4
S/G A Steam Flow (MPPH)	FR-478	.4	.4
S/G B Feedwater Flow (MPPH)	FR-488	.4	.6
S/G B Steam Flow (MPPH)	FR-488	.6	.6
S/G C Feedwater Flow (MPPH)	FR-498	.6	.5
S/G C Steam Flow (MPPH)	FR-498	.4	.5

TABLE 5

STATION ELECTRICAL BLACKOUT

FINAL CONDITIONS

Parameter	Source	Plant Value	Simulator Value
Pressurizer Pressure (Psig)	PR-444	2200	2240
Pressurizer Level (%)	LR-459	22	21
Turbine First Stage Pressure (Psia)	PI-446	N/A	20
T_{avg} (°F)	TR-408	530	548
Loop A ΔT (%)	TI-411B	23	5
Loop B ΔT (%)	TI-421B	34	6
Loop C ΔT (%)	TI-431B	25	4
Power Level (%)	NR-45	0	0
RCS Flow Loop A (%)	FI-415	10	0
RCS Flow Loop B (%)	FI-425	15	0
RCS Flow Loop C (%)	FI-435	10	0
Main Steam Header Pressure (Psig)	PI-464C	780	818
S/G A Steam Pressure (Psig)	PR-475	800	815
S/G B Steam Pressure (Psig)	PR-475	800	800
S/G C Steam Pressure (Psig)	PR-475	800	800
Generator Load (MW_e)	EHC	0	0
S/G A Level (%)	LR-478	52	34
S/G B Level (%)	LR-488	40	34
S/G C Level (%)	LR-498	29	34
S/G A Feedwater Flow (MPPH)	FR-478	0	0
S/G A Steam Flow (MPPH)	FR-478	0	.2
S/G B Feedwater Flow (MPPH)	FR-488	0	0
S/G B Steam Flow (MPPH)	FR-488	.4	.2
S/G C Feedwater Flow (MPPH)	FR-498	0	0
S/G C Steam Flow (MPPH)	FR-498	0	.2

7.0 REFERENCES

7.1 ZPT-9.1, Natural Circulation Demonstration, Revision 0, dated May 25, 1982.

7.2 V. C. Summer Training Simulator Natural Circulation Demonstration, Test 14.4.6.13, Revision 1, dated 6/83.

7.3 HST-7, Pressurizer Spray and Heater Capability and Continuous Spray Flow Settings, Revision 3, dated October 8, 1982.

7.4 V. C. Summer Training Simulator Pressurizer Spray and Heater Capability, Test 14.4.6.3, Revision 1, dated 6/83.

7.5 ZPT-9.2, Core Cooling With a Simulated Loss of Onsite and Offsite AC Power, Revision 0, dated June 6, 1982.

7.6 V. C. Summer Training Simulator Core Cooling With a Simulated Loss of Onsite and Offsite AC Power, Test 14.4.6.14, Revision 1, dated 6/83.

7.7 POT-11, Station Electrical Blackout, Revision 1, dated May 6, 1982.

7.8 EPS-1, Station Blackout Malfunction Test Procedure 14.4.7.6.1, Revision 1, dated 7/11/83.

7.9 Virgil C. Summer Nuclear Station Unit 1 Amended Operating License.

7.10 Summary Startup Test Report, prepared by Five O Consulting Engineering Services, Inc., dated 7/19/83.

7.11 Letter J. C. Miller of Westinghouse to B. G. Croley of SCE&G, CGE-83-565 dated February 21, 1983.