VIRGINIA ELECTRIC AND POWER COMPANY	2 -ST- 11 Revision No.: 0 Date: ________

SPECIAL TEST PROCEDURE FOR NORTH ANNA POWER STATION UNIT # 2

TITLE: EFFECT OF STEAM GENERATOR SECONDARY SIDE ISOLATION ON NATURAL CIRCULATION

Prepared By: R. R. FTLING Date: ________

Engineering Recommended Approval: ________ Date: ________

STATION NUCLEAR SAFETY AND OPERATING COMMITTEE APPROVAL OF PROCEDURE:

Chairman's Signature: ________ Date: ________

All personnel conducting actual testing in accordance with this procedure will verify by their signature that they have read it in its entirety prior to commencing any testing:

________ ________ ________

________ ________ ________

________ ________ ________

________ ________ ________

TEST RESULTS REVIEWED BY ENGINEERING: ________ Date: ________

TEST RESULTS APPROVED BY STATION NUCLEAR SAFETY AND OPERATING COMMITTEE:

Chairman's Signature: ________ Date: ________

Comments: ________

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CHRONOLOGICAL LOG (Use add'l pages as needed) Page __ of ___

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TEST RESULTS (Use additional pages as needed)

DISCREPANCIES (List by number): 10

RESOLUTION OF DISCREPANCIES (List by number corresponding to above): 11

CRITIQUE: 12

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION
UNIT NO. 2

EFFECT OF STEAM GENERATOR SECONDARY SIDE INSOLATION ON NATURAL CIRCULATION

References:

1. Precautions, Limitation and Setpoints for Westinghouse NSSS system
2. Technical Specifications, North Anna Unit No. 2
3. WCAP-8747: North Anna Nuclear Design Report
4. North Anna Station Curve Book
5. 2-OP-5.2

1.0 Purpose

1.1 Determine the effect of steam generator isolation on natural circulation conditions.

1.2 Verify that natural circulation can provide sufficient flow to remove decay heat after partial loss of heat sink.

1.3 Verify that natural circilation can be reestablished in primary loops after steam generators are returned to service.

Initials

2.0 Initial Conditions

_______ 2.1 Reactor is critical and manually controlled at approximately 3% power.

_______ 2.2 All three reactor coolant pumps in operation.

_______ 2.3 Rc coolant system pressure is being maintained at approximately 2235 psig and average coolant temperature is being maintained at approximately 520°F.

_______ 2.4 Steam generator pressure is being maintained at approximately 800 psig using steam dumps in automatic under pressure control.

_______ 2.5 Feedwater to the steam generator will be supplies by the main feedwater system with manual flow control if possible. If previous testing proves additional control is required, the auxiliary feedwater system will be used. Steam generator levels should be maintained at approximately 33% on narrow range indicators.

_______ 2.6 If auxiliary feedwater is to be used, at least 110,000 gallons in the condensate storage tanks are available to supply the steam generators.

_______ 2.7 Steam generator chemistry is in a condition that the absolute minimum steam generator blowdown can be maintained through the test.

_______ 2.8 The 100 psi steamline differential pressure safety injection bistables have been blocked through temporary conditions.

2.9 Brush recorders have been set up to monitor test points at the following locations:

Initials

2.0 Initial Conditions (cont.)

______ 2.9.1 Recorder No. 1 (6 Channel)

Channel	Parameter	Connect To:
1	RCS Flow-Loop 1	FP-414B, C1-432.1
2	RCS Flow-Loop 2	FP-424B, C1-433.1
3	RCS Flow-Loop 3	FP-434B, C1-434.1
5	Pressurize Pressure	PP-455B, C1-427.1
6	Pressurizer Level	LP-459B, C1-442.1

______ 2.9.2 Recorder No. 2 (6 Channel)

Channel	Parameter	Connect To:
1	SG 1 Pressure	PP-474B, C2-443
2	SG 1 Level	LP-474B, C1-429
3	SG 1 Steam Flow	FP-474B, C3-741
4	SG 2 Pressure	PP-484B, C2-444
5	SG 2 Level	LP-484B, C1-430
6	SG 2 Steam Flow	FP-484B, C3-746

______ 2.9.3 Recorder No. 3 (6 Channel)

Channel	Parameter	Connect To:
1	SG 3 Pressure	PP-494B, C2-445
2	SG 3 Level	LP-494B, C1-431
3	SG 3 Steam Flow	FP-494B, C3-748
4	SG A Aux Feed Flow	CC-424
5	SG B Aux Feed Flow	CD-425
6	SG C Aux Feed Flow	CB-426

______ 2.9.4 Record the following on all strip charts:

a) Test Number
b) Recorder QA Number
c) Time and Date
d) Chart Speed
e) Scale Used
f) Test Point
g) Parameter

______ 2.10 Record the following parameters on the reactivity computer recorders:

a. Flux
b. Average wide range T_{cold}
c. Average wide range T_{hot}
d. Average steam generator pressure

Initials

2.0 Initial Conditions (cont.)

______ 2.11 Four incore T/C may be trended as determined by the test engineer on the analog trend recorders in the main control room. It is suggested that these thermocouples be the hottest responding thermocouple in each core quadrant.

______ 2.12 Control Bank D is at approximately 160 steps or as specified by the test engineer to permit reactor power increase up to approximately 3% (required control bank D position may be determined during the hot zero power test program).

______ 2.13 Pressurizer pressure and level control are in automatic, maintaining pressurizer pressure at approximately 2235 psig and level at approximately 22%.

______ 2.14 Normal charging and letdown are in service under automatic control.

______ 2.15 Notify the Shift Supervisor on duty of the impending test and co-ordinate its performance through him.

Initials

3.0 Precautions

______ 3.1 Do not exceed 5% rated thermal power at any time while the test is in progress.

______ 3.2 Do not exceed any of the following temperature limits.

3.2.1 Core exit temperature of 610°F.

3.2.2 ΔT as indicated by $T_H - T_C$ of 100°F.

3.3.3 Tavg of 580.3°F for any loop.

______ 3.3 Maintain reactor coolant pump seal and thermal barrier differential pressure requirements as specified in 2-OP-5.2.

______ 3.4 Avoid any sudden changes in feedwater flow or steam generator level.

______ 3.5 Ensure seal flow to each reactor coolant pump is maintained at or slightly abov 6 gpm during the test.

______ 3.6 After the reactor coolant pumps are tripped, the normal Tavg and ΔT indications will become unreliable. ΔT and Tavg should be calculated by taking the difference and the average of the hot and cold leg temperature indications respectively.

______ 3.7 Do not exceed 1600 psi primary to secondary differential pressure limit.

______ 3.8 Maintain reactor coolant system leg temperatures as stable as possible during system transients. This is required to determine changes in core power level on the NIS channels.

______ 3.9 Because safety injection on high-steamline differential pressures has been disabled, manual safety injection should be initiated if required.

______ 3.10 Do not restart a reactor coolant pump if there is any indication of an excessively high ΔT in any of the loops.

Initials

4.0 Instructions

_______ 4.1 Start brush recorders, at 125 mm/in analog trend recorders, reactivity computer and P-250 trend blocks at one minute intervel.

CAUTION: Following reactor coolant pump trip Tavg and ΔT indication will be unreliable.

_______ 4.2 Simultaneously trip all reactor coolant pumps. Reduce seal water flow to each pump to approximately 6 gpm.

_______ 4.3 Maintain steam generator level at approximately 33%.

NOTE: At initiation of natural circulation the following initial response is expected.

1. Wide range T_{hot}, increase
2. Wide range T_{cold}, slight decrease or constant
3. Core exit thermocouples, increase
4. Pressurizer level, increase

Natural circulation will be stable when:

1. ΔT between wide range T_{hot} and T_{cold} is constant
2. ΔT between wide range T_{cold} and core exit thermocouple average temperature is constant
3. Wide range T_{hot} ≅ core exit thermocouple average temperature

_______ 4.4 Adjust setpoint on steam dump pressure controller PC-2464P as needed to maintain cold leg temperature at the initial values.

_______ 4.5 Adjust setpoints on atmospheric relief valve pressure controllers PCV-MS-201A, B, C for each loop to maintain steam pressure below 1025 psig before isolating any steam generators. This should prevent opening of main steam safety valves.

_______ 4.6 Establish maximum flow through normal letdown path, and manually increase charging flow to maintain a constant RCS water volume. Start an additional centrifugal charging pump if necessary.

CAUTION: Monitor primary to secondary differential pressure very closely during the transient and do not allow it to exceed 1600 psi.

NOTE: Allow the pressurizer level to increase when T_{avg} is increased.

Initials

4.0 Instructions (cont.)

_______ 4.7 Close MOV-FW-2554C, TV-MS-201C and TV-MS-213C. Isolate steam generator to C. Carefully control feedwater additions to the remaining steam generators to hold the levels at approximately 33%. It will be necessary to adjust the steam dump pressure controller setpoint to reduce T_{cold} in the unisolated loops so that the steam generator pressure in the isolated loop remains below the setpoint of the atmospheric relief valve.

NOTE: During the transient the following responses can be expected.

1. Wide range T_{hot}, slight increase
2. Wide range T_{cold} for Loop C, increase
3. Wide range T_{cold} for other loops, decreased using steam dump
4. Core exit thermocouples, slight increase

_______ 4.8 Allow natural circulation conditions to stabilize. Steady state should be achieved when the calculated loop C ΔT is approximately zero.

_______ 4.9 Verify that the calculated value for Tavg for the remaining 2 loops have stabilized. If Tavg continues to increase and cannot be stabilized the test engineer should determine whether further testing can be conducted.

_______ 4.10 Slowly reduce the setpoint on atmospheric relief valve controller PC-2464B and reduce steam dump to condenser, allowing steam generator #C to reach approximately equilibrium with steam pressure of 1005 psig.

_______ 4.11 Slowly open PCV-MS-201C to equalize pressure with steam header if necessary. Open TV-MS-213C and the TV-MS-201C to unisolate "C" steam generator. Open MOV-FW-2554C and maintain steam generator level at $\approx$ 33%.

Initials

4.0 Instructions (cont.)

NOTE: During the transient the following responses can be expected.

1. Wide range Thot, decrease
2. Wide range Tcold for loop C, decrease
3. Wide range Tcold for loops, A and B, increase using steam dump

_______ 4.12 Allow natural circulation conditions to stabilize. Steady state should be achieved when the calculated loop ΔT's are approximately equal.

_______ 4.13 Stop recording test data.

_______ 4.14 Insert control bank D until the reactor is in the hot zero power test range.

CAUTION: Ensure pressurizer spray controllers are at zero output prior to starting the first reactor coolant pump.

_______ 4.15 Restart all three reactor coolant pumps in accordance with 2-OP-5.2.

Completed By: ______________________

Date: ______________________

Initials

5.0 Acceptance Criteria

_______ 5.1 Core exit thermocouple temperature does not exceed 610 degrees Fahrenheit.

_______ 5.2 ΔT for any loop does not exceed 100 degress Fahrenheit.

_______ 5.3 Tavg for any loop does not exceed 580.3 degrees Fahrenheit.

_______ 5.4 Sufficient natural circulation could be maintained in active primary loops to maintain stable temperatures following partial loss of heat sink.

_______ 5.5 Natural circulation could be restored to the inactive loop when associated the steam generator were returned to service.

6.0 Attachments

6.1 Test Equipment Data Sheet

6.2 Initial Conditions

6.3 Primary Caloremetric

6.4 Process Computer Trend Block Data

TEST EQUIPMENT DATA SHEET

TEST EQUIPMENT DESCRIPTION*	MODEL NUMBER	VEPCO QA NUMBER

* NOTE: This applies only to temporarily installed test equipment or instrumentation Permanent instrumentation which is part of the system and shown on drawings should not be included.

Completed By: ______________________

Date: ______________________

INITIAL CONDITIONS

Pressurizer Pressure PR-2444 Red Pen	____________________	psig
Pressurizer Level LR-2459 Red Pen	____________________	%
RCS Loop 1 Hot Leg Temperature TR-2413 Red Pen	____________________	°F
RCS Loop 1 Cold Leg Temperature TR-2410 Red Pen	____________________	°F
RCS Loop 2 Hot Leg Temperature TR-2423 Green Pen	____________________	°F
RCS Loop 2 Cold Leg Temperature TR-2420 Green Pen	____________________	°F
RCS Loop 3 Hot Leg Temperature TR-2433 Blue Pen	____________________	°F
RCS Loop 3 Cold Leg Temperature TR-2430 Blue Pen	____________________	°F
Steam Generator 1 Level (NR) (LI-2474)	____________________	%
Steam Generator 2 Level (NR) (LI-2484)	____________________	%
Steam Generator 3 Level (NR) (LI-2494)	____________________	%
Steam Generator 1 Level (WR) LR-2477 Pen 1 Red Pen	____________________	%
Steam Generator 2 Level (WR) LR-2477 Pen 2 Green Pen	____________________	%
Steam Generator 3 Level (WR) LR-2477 Pen 3 Blue Pen	____________________	%

INITIAL CONDITIONS

Steam Generator 1 Pressure PI-2474	______	psig
Steam Generator 2 Pressure PI-2484	______	psig
Steam Generator 3 Pressure PI-2494	______	psig
Steam Generator 1 Feedwater Flow (FI-2476)	______	$X10^6$ #/hr
Steam Generator 2 Feedwater Flow (FI-2486)	______	$X10^6$ #/hr
Steam Generator 3 Feedwater Flow (FI-2496)	______	$X10^6$ #/hr
Steam Generator 1 Steam Flow (FI-2474)	______ $X10^6$	lbs/hr
Steam Generator 2 Steam Flow (FI-2484)	______ $X10^6$	lbs/hr
Steam Generator 3 Steam Flow (FI-2494)	______ $X10^6$	lbs/hr
Loop 1 Tavg protection (TI-2412D)	______	°F
Loop 2 Tavg protection (TI-2422D)	______	°F
Loop 3 Tavg protection (TI-2432D)	______	°F

INITIAL CONDITIONS

Loop 1 ΔT protection (TI-2412A) ____________________ %

Loop 2 ΔT protection (TI-2422A) ____________________ %

Loop 3 ΔT protection (TI-2432) ____________________ %

NIS Channel N-41 ____________________ %

NIS Channel N-42 ____________________ %

NIS Channel N-43 ____________________ %

NIS Channel N-44 ____________________ %

Attach a copy of the computer printout of the Incore Thermocouple Temperature map.

Completed By: ____________________

Date: ____________________

APPENDIX A

Outline

I. Core Power Determination

A. Primary Side Calorimetric (Forced Circulation Only)

1. Reference (~550°F) Calorimetric

a) Output used to adjust M/D Power Monitor Program's power conversion constant.

B. M/D Power Monitor Program

1. Power Conversion Constant Adjustment.

a) The output of the REF primary calorimetric will give a % power output. this output must be input to the M/D Power-Monitor Program so that the program output will be in percent power and equal to the primary calorimetric output.

2. Power Monitoring

a) The M/D Power Monitor Program will calculate the integral power as seen by one pass of 4 or 5 detectors. After the output has been calibrated to be equal to the REF primary calorimetric it will be rerun up to once every 2 minutes or as necessary to continuously monitor core power.

APPENDIX A
CORE POWER DETERMINATION

PART A: Primary side calorimetric - Data Sheet A.1 (Forced Circulation)

A.1 Use two DVMs and measure the voltage at the test points specified for each loop as rapid as possible.

A.2 Calculate the Δ T; multiply that Δ T by the specific heat and the Westinghouse best estimate flow rate of the core average temperature (Table A-1). (Special Test No. 9 uses wide range Δ T so a correction factor is required to compensate for pump heating, refer to Appendix B of 2-ST-7).

A.3 Sum the loop heat rates and convert to a percent reactor power. The output is used in Part B.

APPENDIX A (Continued)
Core Power Determination

PART B: M/D Power Monitor Program

1. Set up the movable detector system for a 1 pass partial core flux map. Select flux thimbles as per the table below for the flux map.

Drive	10-Path Position	Core Location
A		
B		
C		
D		
E		

These positions may be altered by the test engineer, based upon low-power physics testing results and previous special testing experience.

2. Determine the detector normalization constants and enter them into the P-250 as follows:

   a) Enter a value of 1.0 into the P-250 for the addresses shown in the table below.

   b) With all 5-path selector switches set to normal, run a flux trace.

   c) With all 5-path selector switches set to Emergency, run a second flux trace.

   d) Determine the detector normalization constants from Data Sheet A.1.

   e) Enter these detector normalization constants into the P-250 as shown in the table below.

Drive	P-250 Address	Constant
A		
B		
C		
D		
E		

APPENDIX A (Continued)
Core Power Determination

PART B: (Continued)

3. Verify that the P-250 parameters listed in the following table have the proper value and that the P-250 time and date are current. Update as required.

Address	Value	Function
K0901	1	Set the power normalization factor
K3325	1	Selects the modified "Flux Map Print" programs
K0900	0	Initiated Pass Number
K0864	Variable(1)	Calibration Constant for M/D Power Monitor

(1) Variable: The value entered is a ratio of the Primary Calorimetric Indicated Power (Item 3 on Data Sheet C.1) to the M/D calculated power (U0906) times the current value entered in (K0864). If no value has been entered into (K0864) enter 0.25.

$$\text{New (K0864)} = \text{Current (K0864)} \times \frac{\text{Item \#8 Data Sheet C.1}}{\text{(U0906)}}$$

4. For power determination, obtain a partial core flux map. The M/D's need not be withdrawn between passes, and passes may be repeated as often as a power determination is required.

NOTE: The calculated power (U0906) is printed after each pass and may be trended by the P-250 if desired. The individual detector normalized integrals are also printed.

APPENDIX A (Continued)

TABLE A-1

Temp °F	C_p (1) BTU/lbm°F	$\dot{m}$ lbm/hr
556	1.260	3.6448×10^7
554	1.255	3.6553×10^7
552	1.250	3.6659×10^7
550	1.245	3.6765×10^7
548	1.240	3.6862×10^7
546	1.236	3.6959×10^7
544	1.231	3.7057×10^7
542	1.226	3.7155×10^7
540	1.221	3.7254×10^7
538	1.217	3.7348×10^7
536	1.213	3.7443×10^7
534	1.209	3.7538×10^7
532	1.206	3.7633×10^7
530	1.202	3.7729×10^7

(1) These values are from the 1967 ASME Steam Tables. Values are for a pressure of 2250 psia.

POOR ORIGINAL

APPENDIX A (Continued)

Data Sheet A.1

Date ________ Time ________ Unit ________ Power ________ Tavg ________ °F

Item #	Calculation Procedure	Units	Loop 1	Loop 2	Loop 3
1	Loop Δ T - Inservice (at test point)	Volts			
2	Loop Δ T = (#1) x [(1)]	°F			
3	Loop Δ H = (#2) x Cp (from Table A.1)	BTU/lbm			
4	Loop RCS Flow (from Table A.1)	10^6 lbm/hr			
5	Loop Reactor Power = (#3) x (#4)	10^6 BTU/hr			
6	Total Reactor Power = (#5) Loop 1 + Loop 2 + Loop 3	10^6 BTU/hr			
7	Reactor Power = (#6) x 0.29307	MWT			
8	% Reactor Power = (#7) x 0.02932	%			

(1) Conversion factor for Δ T obtained from scaling document.

Remarks:

Data By: ________

Date: ________

APPENDIX A (Continued)

DATA SHEET A.2

A_N = ____ B_N = ____ C_N = ____ D_N = ____ E_N = ____

A_E = ____ B_E = ____ C_E = ____ D_E = ____ E_E = ____

$N_A = 1.00$

$$N_B = \frac{A_N}{B_N} = \frac{N_A A_E}{B_N} = \_\_\_\_\_\_$$

$$N_C = \frac{A_N}{C_N} = \frac{N_B B_E}{C_N} = \_\_\_\_\_\_$$

$$N_D = \frac{A_N}{D_N} = \frac{N_C C_E}{D_N} = \_\_\_\_\_\_$$

$$N_E = \frac{A_N}{E_N} = \frac{N_D D_E}{E_N} = \_\_\_\_\_\_$$

Definitions:

A_N, B_N, C_N, D_N, E_N = Normalized integral from summary map for each detector in a normal path in the first pass

A_E, B_E, C_E, D_E, E_E = Normalized integral from summary map for each detector in an emergency path in the second pass

N_A, N_B, N_C, N_D, N_E = Detector normalization factor for each detector

Remarks:

POOR ORIGINAL

Data By: ____________________ Date ____________

APPENDIX A (Continued)

Part C: Using Thermocouples

The incore thermocouples can be used as an indication of both core flow distribution and power shifts during natural circulation.

Prior to running a thermocouple map or trending the eight quadrant tilts (four center line and four diagonal tilts) the following should be verified:

K0701-K0765 = 1, For the flow mixing factors

K3501 = 0, Indicates the measured core ΔT is unreliable

K0791 = 0.075, Core bypass flow fraction

K5010 = 8, Tells thermocouple program how many readings of thermocouples are required for averaging before calculation is done. This in turn sets the running frequency of the Thermocouple Averaging Program at 1, 2, ... X 8 seconds or 64 seconds for us.

The thermocouple programs breaks the core down into eight quadrants—four centerline and four diagonal quadrants (see Figure C-1). Quadrants 1-4 can be directly correlated with the excore detectors but quadrants 5-8 cannot.

The quadrant tilts are indicative of power shifts and should be trended at approximately a 2-minute frequency. The following addressable values are the quadrant tilts:

Quadrant	Addressable Value
1	U1159
2	U1160
3	U1161
4	U1162
5	U1151
6	U1152
7	U1153
8	U1154

A Short Form Map should be run periodically or upon request from the test engineer as an indication of core flow distribution. It should be put on the Utility Typewriter if possible. The P-250 Operator's Console Reference Manual provides instructions for obtaining thermocouple maps.

The trend output and Short Form Maps should be attached to this procedure at the end of the test.

PROCESS COMPUTER TREND BLOCK A

COLUMNS	ADDRESS	PARAMETER	UNITS
1	T0406A	RCL A T_{COLD}	°F
2	T0426A	RCL B T_{COLD}	°F
3	T0446A	RCL C T_{COLD}	°F
4	T0419A	RCL A T_{HOT}	°F
5	T0939A	RCL B T_{HOT}	°F
6	T0959A	RCL C T_{HOT}	°F
7	T0400A	T_{AVG} LOOP A	°F
8	T0420A	T_{AVG} LOOP B	°F
9	T0440A	T_{AVG} LOOP C	°F
10	T0403A	ΔT LOOP A	%
11	T0423A	ΔT LOOP B	%
12	T0443A	ΔT LOOP C	%
13	F0128A	CHARGING FLOW	GPM
14	F0134A	LETDOWN FLOW	GPM
15	U1250	HIGHEST REL FUEL ASSY PWR	
16	L0480A	PRESSURIZER LEVEL	%
17	L0112A	VCT LEVEL	%
18	U1251	HIGHEST REL ASSY PWR INDENT	

PROCESS COMPUTER TREND BLOCK B

COLUMNS	ADDRESS	PARAMETER	UNITS
1	L0400A	S/G A LEVEL	%
2	L0420A	S/G B LEVEL	%
3	L0440A	S/G C LEVEL	%
4	P0400A	S/G A PRESS	PSIG
5	P0420A	S/G B PRESS	PSIG
6	P0440A	S/G C PRESS	PSIG
7	P0480A	PRESSURIZER P	PSIG
8	P0498A	RCL SYSTEM P	PSIG
9	P0142A	CHARGING PRESS	PSIG
10	U0482	AVG PZR PRESS	PSIG
11	U0483	AVG PZR LEVEL	%
12	U1118	RX THERMAL POWER	MW
13	U1170	AVG T/C TEMP	°F
14	AS REQUIRED	HOTTEST T/C (QUADRANT 1)	°F
15	AS REQUIRED	HOTTEST T/C (QUADRANT 2)	°F
16	AS REQUIRED	HOTTEST T/C (QUADRANT 3)	°F
17	AS REQUIRED	HOTTEST T/C (QUADRANT 4)	°F