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NO ACKNOWLEDGEMENT REQUIRED

A001

FLORIDA POWER

CRYSTAL RIVER UNIT 3

PLANT OPERATING MANUAL

EM-225D

GUIDANCE FOR DRY OTSG TUBE TO SHELL DELTA T MONITORING AND CONTROL

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1.0 PURPOSE

The purpose of this procedure is to provide guidance to the TSC Accident Assessment Team (AAT) to monitor OTSG conditions that may challenge OTSG tube-to-shell delta T limits, and provide recommendations to the Emergency Coordinator and Control Room on methods to prevent delta T limits from being exceeded.

These guidelines are applicable when a dry OTSG does not have integrity and cannot be recovered using EOP-14, Enclosure 3, "Dry OTSG Recovery."

2.0 REFERENCES

2.1 Developmental References

2.1.1 Framatome Technology Letter INS-97-4651, dated 11/25/97

2.1.2 FTI Document No. 51-1224886-02, OTSG Refill Summary Report

2.1.3 FPC Calculation M97-0156, CR-3 EOP Natural Circulation Tube Loads (FTI Document No. 51-1266247-00)

2.1.4 Emergency Operating Procedures Technical Bases Document, Volume 1

3.0 PERSONNEL INDOCTRINATION

3.1 Definitions

3.1.1 **Dry OTSG** - Any OTSG with an indicated level of ≤ 12.5 inches as read on the EFIC low range level instruments.

3.1.2 **OTSG integrity** - OTSG integrity exists if the secondary side pressure boundary is intact, allowing an OTSG to pressurize when supplied with feedwater.

3.1.3 **Shell Temperature** - The temperature of the bulk of the metal composing the shell of an OTSG. Shell temperature on a dry OTSG will lower over time as heat is lost to the Reactor Building. The shell is estimated to cool at approximately 6°F/hour. Figure 1 provides an estimate of shell temperature versus time.

3.1.4 **Tincore** - The temperature indication supplied by the incore thermocouples to SPDS, Tsat monitors and the core exit temperature recorders in the Control Room. Tincore is used to estimate average OTSG tube temperature when at least 1 RCP is running. Tincore can be determined from SPDS, or if SPDS is not available, use average Tincores from the core exit chart recorders on the MCB (RC-171-TR, RC-172-TR).

3.1.5 **Tube Temperature** - The temperature associated with the tubes of an OTSG. Tube temperature can be determined using Tincore when at least 1 RCP is running. If no RCPs are running, tube temperature can only be estimated if natural circulation exists in the OTSG. Natural Circulation will only occur if the dry OTSG is being fed. If natural circulation exists, Thot can be used to approximate tube temperatures.

3.1.6 **Tube to shell delta T** - The difference between OTSG tube temperature and the OTSG shell temperature. If the tubes are hotter than the shell, the tubes are in compression (compressive stress). If the tubes are colder than the shell, the tubes are in tension (tensile stress).

3.2 **Responsibilities**

3.2.1 **TSC Accident Assessment Team:** Responsible for monitoring OTSG conditions that may result in excessive tube to shell delta T caused by a dry OTSG, and to recommend actions to the Emergency Coordinator and the Control Room to minimize tube stresses under these conditions.

3.2.2 **Emergency Coordinator:** Responsible for reviewing and approving all recommendations provided by the Accident Assessment Team prior to implementation by the Control Room staff.

3.3 **Limits And Precautions**

3.3.1 Initiating a source of feedwater to an OTSG that does not have integrity must be carefully evaluated and planned to prevent harm to personnel and damage to vital plant equipment.

3.3.2 If either ES 4160 volt bus is energized from an emergency diesel generator, then prior to starting any ES powered component ensure adequate load margin is available on the EDG. Refer to EOP-13, Rule 5.

3.3.3 Establishing feedwater flow to a faulted OTSG with a feedwater or steam line break in the Reactor Building could dilute sump recirculation fluid if a LOCA was in progress or subsequently occurs.

3.3.4 OTSG tube compression limit (tubes hotter than shell) is 60°F.

3.3.5 OTSG tube tensile limit (tubes cooler than shell) is 100°F.

3.3.6 All actions recommended to the Control Room as a result of this procedure must be pre-approved by the Emergency Coordinator.

3.3.7 The operating crew and the TSC staff should monitor for indications of a steam generator tube leak during the RCS cooldown.

4.0 **INSTRUCTIONS**

4.1 **General Guidelines**

4.1.1 Begin estimating OTSG shell temperature by using Figure 1. The OTSG shell is expected to cooldown at approximately 6°F/hour from the time the OTSG becomes dry. When using Figure 1, Time = 0 is based on when the OTSG boiled dry.

4.1.2 IF a steam or feedline failure has not occurred in the Reactor Building,
AND shell temperatures appear accurate,
THEN monitor shell temperatures using shell thermocouples referenced below. The shell thermocouples may provide useful trend data.

A-OTSG	**A-730,731,732,733,734**	Average R-771
B-OTSG	**A-735,736,737,738,739**	Average R-772

4.1.3 IF shell thermocouples are accurate,
THEN adjust 6°F/hour cooldown rates as necessary to control tube to shell delta T limits.

4.1.4 Begin plotting RCS temperature from Tincores on Figure 1. Tincore is an accurate indication of OTSG tube temperature only if forced flow (at least 1 RCP running) exists. Natural Circulation is not expected to exist on the faulted OTSG, therefore OTSG tube temperature is indeterminate. HPI flow or seal injection flow may result in false Tc indications even if natural circulation conditions exist.

4.1.5 If integrity is restored to a dry OTSG, it should be fed using EOP-14, Enclosure 3 "Dry OTSG Recovery." Once OTSG level is recovered to > 12.5", this procedure may be exited.

4.1.6 If a SBLOCA or RCS leak is in progress concurrent with a dry OTSG, HPI flow may result in RCS cooldown limits being in excess of 6°F/hour on the dry OTSG. Minimize OTSG cooling on the intact OTSG and attempt to maintain RCS temperature above the minimum RCS temperature curve in Figure 1 if forced flow exists. The minimum RCS temperature curve was generated assuming forced flow exists.

4.1.7 Prior to recommending feeding a faulted OTSG, determine if additional steaming could result in a personnel safety hazard or plant equipment damage.

4.1.8 IF a feedwater or steam line failure has occurred in the Reactor Building,
THEN ensure that Emergency RB Cooling is in service prior to initiating flow to a faulted OTSG. Monitor RB temperature and pressure during feeding.

4.1.9 IF a LOCA is in progress,
AND a feedwater or steam line failure has occurred in the Reactor Building,
THEN do not feed the faulted OTSG. Feeding the OTSG will result in dilution of the RB Sump recirculation fluid.

4.1.10 IF a feedwater or steam line failure has occurred in the Reactor Building,
AND a LOCA is not in progress,
THEN the RB sump pumps must remain in service to pump condensation from the Reactor Building sump. This may require bypassing ES and reopening WDV-3 and WDV-4. Begin processing water from the Miscellaneous Waste Storage Tank per OP-407R as soon as possible. Processing rates are 30 to 40 gpm.

4.1.11 Minimize subcooling margin based on Tincore to minimize tube pressure stresses.

4.1.12 Any source of feedwater flow to a dry OTSG must be established to the upper (EFW) nozzles to minimize tube stresses.

4.1.13 Determine appropriate section to be used based on RCP status. Enclosure 1 is presented in a logical format as an additional reference and presents the guidance contained in both sections.

IF any RCP is running,
THEN use Section 4.2.

IF no RCP is running,
THEN use Section 4.3.

4.2 Forced Flow Guidelines

4.2.1 When at least one RCP is running, tube to shell delta T can be maintained within limits by cooling down the RCS at approximately 6°F/hour using the good OTSG. This cooldown rate is the estimated cooldown rate of the OTSG shell and will minimize differential thermal expansion between the tubes and shell.

4.2.2 IF the 6°F/hour rate is not achieved or is exceeded,
THEN the cooldown for the following hour must be adjusted accordingly (i.e., increase or decrease cooldown to achieve a 12°F temperature change over the total 2 hour period).

4.2.3 Plot RCS temperature (Tincores) versus time on Figure 1 to estimate tube to shell differential temperature. Tincores provide reliable indication of tube temperatures when RCPs are running. Use SPDS to determine incore temperature.
IF SPDS is not available,
THEN use average Tincores from the core exit chart recorders on the MCB to determine RCS temperature (RC-171-TR, RC-172-TR).

4.2.4 Maintain Tincore above the "Min RCS Temp" curve shown in Figure 1 to prevent challenging the tensile limit of the tubes.
IF RCS temperature approaches the "Min RCS Temp" limit,
THEN stop or minimize the cooldown. This minimum temperature limit is only applicable when any RCP is operating.

4.3 Natural Circulation Guidelines

4.3.1 With no RCPs running, natural circulation will not exist in the loop with the dry OTSG. Since the reactor coolant in the affected OTSG tubes is stagnant, cooling the RCS at 6°F/hour will not be an effective means to minimize tube to shell delta T on the dry OTSG.

4.3.2 With no RCPs running, the dry OTSG may exceed tube to shell compressive limits if feeding does not occur within approximately 5 hours.

4.3.3 IF forced flow is restored,
THEN cooldown the RCS within ITS limits (see cooldown tables in EOPS) using the good OTSG to equalize RCS temperature (Tincore) with the estimated shell temperature from Figure 1. Forced flow will provide a means to monitor and cooldown the idle OTSG. RCP restart guidance is included in EOP-14, Enclosure 16. Continue the RCS cooldown at a rate of approximately 6°F/hour and use the forced flow guidance in Section 4.2.

4.3.4 IF an RCP cannot be started,
THEN determine if the hot leg on the dry OTSG is saturated or subcooled by requesting a reading of the Tsat monitor in the Control Room when the loop is selected for "Thot" or by use of the steam tables.

4.3.5 IF the dry OTSG hot leg is subcooled,
AND the steaming path is acceptable,
THEN perform the following:

- o Establish EFW or AFW flow to the affected OTSG at < 300gpm to initiate natural circulation through the idle loop.
- o Control flow to both the intact and faulted OTSG to prevent exceeding ITS cooldown rates.
- o Attempt to equalize Thot with the estimated shell temperature of Figure 1 to limit the compressive tube to shell delta temperature.
- o Terminate flow to affected OTSG if steaming the faulted OTSG is causing a hazard to personnel or vital plant equipment.
- o IF OTSG integrity is restored,
  THEN feed the dry OTSG per EOP-14, Enclosure 3 "Dry OTSG Recovery."
- o Cooldown the RCS at approximately 6°F/hour to attempt to track the shell cooldown rate. The "Min RCS Temp" curve is not applicable with no RCP in operation.
- o WHEN DH is established,
  THEN ensure high point vents are closed.

4.3.6 If the dry OTSG hot leg is saturated,
AND the steaming path is acceptable,
THEN perform the following:

1. Estimate OTSG tube temperature on the faulted OTSG using Tsat of the primary side, based on RCS Psat.
2. Stop the cooldown.
3. Ensure RB cooling is in service prior to opening high point vent valves. Opening the high point vents may result in Reactor Building Pressure reaching the ES actuation setpoint (4 psig nominal) and raise Reactor Building temperature.
4. Anticipate inventory makeup to the RCS and open the high point vent valves to reduce or eliminate the void.
5. Establish EFW or AFW flow to the affected OTSG at a rate of 250 gpm for 1 minute.
6. IF OTSG integrity is restored,
   THEN feed the dry OTSG per EOP-14, Enclosure 3, "Dry OTSG Recovery."
7. IF natural circulation cannot be induced and the faulted OTSG cannot repressurize, THEN do not reinitiate EFW unless the hot leg becomes subcooled due to natural circulation or by performance of Step 4.3.7.
8. IF the hot leg does become subcooled,
   THEN follow the guidance in Step 4.3.5.
9. Cooldown the RCS at approximately 6°F/hour to attempt to track the shell cooldown rate. The "Min RCS Temp" curve is not applicable with no RCP in operation.

4.3.7 <u>IF</u> the dry OTSG hot leg remains <u>saturated</u> after feeding for 1 minute,
<u>OR</u> a safe steaming path is not available,
<u>THEN</u> perform the following:

- o Consider opening the high point vent valves on the idle hot leg to limit the tube temperature.
  - Flow through the high point vent will allow cooler RCS to refill the hot leg and lower compressive tube stresses.
  - Opening the high point vent may result in Reactor Building Pressure reaching the ES actuation setpoint (4 psig nominal) and raise Reactor Building temperature.
  - Opening the high point vent will require HPI flow to prevent loss of subcooling margin based on Tincores.
  - RB cooling should be in service prior to opening high point vent valves.
  - <u>IF</u> the hot leg becomes subcooled as a result of opening the high point vents, <u>THEN</u> close the high point vents and feed the Dry OTSG per Step 4.3.5.
- o <u>IF</u> feeding the OTSG is not possible,
  <u>THEN</u> cycle the high point vents as required to continue a cooldown of the idle hot leg.
- o Cooldown the RCS at approximately 6°F/hour to attempt to track the shell cooldown rate. The "Min RCS Temp" curve is not applicable with no RCP in operation.

DRY OTSG DECISION MATRIX

	≥ 1 RCP **RUNNING**	NO RCP RUNNING AND IDLE HOT LEG SUBCOOLED	NO RCP RUNNING AND IDLE HOT LEG SATURATED
OTSG INTEGRITY EXISTS AND SOURCE OF FW AVAILABLE	MINIMIZE SUBCOOLING MARGIN FEED DRY OTSG PER EOP-14 ENCLOSURE 3. EXIT THIS PROCEDURE WHEN OTSG IS RECOVERED.	MINIMIZE SUBCOOLING MARGIN FEED DRY OTSG PER EOP-14 ENCLOSURE 3. EXIT THIS PROCEDURE WHEN OTSG IS RECOVERED.	MINIMIZE SUBCOOLING MARGIN VENT THE HOT LEG TO ELIMINATE THE VOID FEED FAULTED (DRY) OTSG AT 250 GPM FOR 1 MINUTE. If OTSG REPRESSURIZES, THEN FEED DRY OTSG PER EOP-14 ENCLOSURE 3. EXIT THIS PROCEDURE WHEN OTSG IS RECOVERED.
OTSG INTEGRITY DOES NOT EXIST	MINIMIZE SUBCOOLING MARGIN ESTABLISH AND MAINTAIN RCS COOLDOWN AT ≈ 6°F/HR. DO NOT ALLOW RCS TEMPERATURE (BASED ON Tincores) TO COOL BELOW THE MINIMUM RCS TEMPERATURE LIMIT OF FIGURE 1.	MINIMIZE SUBCOOLING MARGIN FEED FAULTED (DRY) OTSG < 300 GPM IF STEAMING PATH IS ACCEPTABLE. MAINTAIN COOLDOWN RATES WITHIN ITS LIMITS. EQUALIZE Thot WITH ESTIMATED SHELL TEMP ON FIGURE 1 WHEN NATURAL CIRCULATION IS ESTABLISHED, CONTINUE RCS COOLDOWN AT 6°F/HR.	MINIMIZE SUBCOOLING MARGIN VENT THE HOT LEG TO ELIMINATE THE VOID FEED FAULTED (DRY) OTSG < 250 GPM FOR 1 MINUTE IF STEAMING PATH IS ACCEPTABLE. IF HOT LEG BECOMES SUBCOOLED, THEN CONTINUE FEEDING AT < 300 GPM IN ACCORDANCE WITH THE GUIDANCE FOR A SUBCOOLED HOT LEG. IF HOT LEG REMAINS SATURATED, DO NOT RE-FEED OTSG UNLESS OTSG INTEGRITY IS RESTORED. IF STEAMING PATH IS NOT ACCEPTABLE, OR THE HOT LEG REMAINS SATURATED AFTER A 1 MINUTE FEEDING, CONSIDER CYCLING HIGH POINT VENT ON THE HOT LEG OF THE FAULTED OTSG IF CONTAINMENT CONDITIONS PERMIT. CONTINUE RCS COOLDOWN AT 6°F/HR.

MINIMUM RCS TEMPERATURE CURVE