FPL

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L-2003-286

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D. C. 20555

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Request for Additional Information Regarding
Station Blackout Analysis (TAC Nos. MB8728 and MB8729)

By letter dated October 16, 2003, the NRC issued a request for additional information regarding the Station Blackout (SBO) analysis for Turkey Point Units 3 and 4. The information is needed to resolve Unresolved Item No. 50-250 (251)/02-06-01, "Adequacy of Station Blackout (SBO) Strategy/Analysis and Loss of AC Power Emergency Operating Procedures." The response to the request for additional information is provided in the attachment to this letter.

Please contact Walter Parker at (305) 246-6632 if there are any questions.

Very truly yours,

Terry O. Jones
Vice President
Turkey Point Nuclear Plant

OIH

Attachment

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant

A001

Response To NRC Request for Additional Information Regarding Station Blackout Analysis for Turkey Point Units 3 and 4

This attachment documents the responses to the NRC request for additional information on the station blackout (SBO) RETRAN coping analysis for Turkey Point Units 3 and 4 (PTN-ENG-SENS-02-065). The purpose of that coping analysis was to demonstrate that Turkey Point Units 3 and 4 have maintained compliance with their licensing basis following procedure changes that modified the method of cooling the reactor coolant pump (RCP) shaft seals under SBO conditions. The analysis was performed to address a 2002 NRC inspection team concern that the revised SBO recovery strategy could result in additional RCS makeup requirements due to the additional leakage expected from the RCP shaft seals and the reactor coolant shrinkage that occurs with a cooldown. The inspection team could not confirm that these potential additional makeup requirements were properly evaluated.

To address the NRC inspection team concern, an engineering calculation (PTN-BFJF-02-142) was performed to document the analysis of two SBO scenarios intended to demonstrate that the affected Unit could cope with higher RCS inventory losses. One scenario was designed to introduce RCS shrinkage (Cooldown SBO Scenario). This scenario assumed operator action to initiate a 25 °F/hr controlled plant cooldown as early as 30 minutes into the event via atmospheric steam dump valve (ADV) operation. This cooldown rate is consistent with the plant's Natural Circulation Cooldown Emergency Operating Procedure. It is important to note that assuming a cooldown of the RCS results in a conservative SBO scenario. The second scenario, the Hot Standby SBO scenario, was designed to investigate the potential challenge to the containment and is the same as the first scenario except that it assumes no operator action to cooldown the plant.

The thermal-hydraulic analysis was performed with the RETRAN 02 computer code and the Turkey Point RETRAN Base Model. Florida Power and Light Company has been using this computer code since the mid-1980's to support operation at Turkey Point Units 3 and 4 and St. Lucie Units 1 and 2. During this time, various RETRAN models have been prepared and verified by benchmarking the calculation results to actual plant test data, and to UFSAR analyses. The spectrum of analyses and benchmarks performed to date for the four Units validates FPL's ability to accurately apply the RETRAN Base Models to complex transients and obtain results similar to those obtained by outside vendors.

1. ***The RETRAN code has been accepted generically by the U.S. Nuclear Regulatory Commission (NRC) staff for reactor transients. The NRC staff does not consider RETRAN suitable for loss-of-coolant accident (LOCA) analyses. This results from the code not being qualified against appropriate separate effects tests and integral experiments for phenomena expected during conditions of a LOCA. These conditions involve a sufficient reduction in primary inventory that produces a steam bubble in the upper head while voiding in the steam generators (SGs) creates a steam condensation environment necessary for heat removal. While the event in question is a very small LOCA, it is pertinent to demonstrate that RETRAN is capable of simulating this type of event.***

The Turkey Point Cooldown Station Blackout (SBO) scenario, (analyzed to confirm that a procedural change did not challenge core cooling with the effects of RCS shrinkage), is more of a cooldown event than a LOCA. However, since there is small RCS leakage, beyond the assumed capability of available charging pump capacity, the scenario is categorized as a Small Break LOCA (SBLOCA). RCS voiding during the event is essentially confined to the vessel upper head. The operator driven cooldown/depressurization, with the opening of the Atmospheric Dump Valves (ADV), results in the temperature of the vessel upper head region exceeding its saturation temperature and therefore causing voiding in the region to occur. The voiding, however, is essentially confined to that region and at no time during the event is natural circulation challenged. The hot legs remain subcooled throughout the event and at no point was core cooling challenged.

In addition to the Cooldown SBO analysis, another analysis was performed for the same scenario but at hot standby conditions without the forced cooldown. This second analysis, referred to as the Hot Standby SBO analysis, was intended to address concerns of containment integrity with a continuous 8-hour leakage of RCS fluid at hot standby conditions into containment. As the answer to Question 6 shows, for the Hot Standby scenario, charging is capable of slowly refilling the system from the time it is started at 30 minutes. This scenario, therefore, is not categorized as a LOCA and is analyzed only to assess containment response (see answer to Question 8).

The following responses to Questions 1.a through 1.i are addressed only for the RETRAN analysis of the Cooldown SBO scenario.

a. *Describe the benchmarks of RETRAN against integral system and separate effects testing to demonstrate that RETRAN can simulate a cooldown of the reactor coolant system (RCS) with the head voided and condensation characterizing the heat removal in the steam generators. Include comparisons of RETRAN to separate effects, as well as Integral data (for example, comparisons of the code to condensation tests, the MIT pressurization tests, Marviken critical flow, Containment Systems Experiments and GE blowdown experiments, etc).*

For the Cooldown SBO scenario analyzed, interruption of natural circulation and condensation phenomena at the top of the steam generator (SG) tubes (primary side) is not predicted to occur. This is because, for the duration of the event, voiding is confined to the vessel upper head and the hot legs remain covered and subcooled. Therefore, benchmarks of the RETRAN code capabilities against these phenomena are not considered necessary for this application.

b. *Provide a discussion of the amount of condensation calculated during the event. This discussion should include a plot of the injection rate, condensation rate, break flow rates, and break qualities versus time for the event.*

As discussed above, no condensation phenomena are predicted to occur during the Cooldown SBO scenario analyzed.

The only fluid injections to the RCS are from the charging system and the accumulators. The charging system provides a constant flow of 72 gpm of water above 100 °F, starting at 30 minutes into the event. The three accumulators are modeled to start discharging when the pressure in the cold leg drops below 600 psig.

c. *Describe the modeling of the break, including whether or not the slip model was used.*

The RCS leakage consists of two parts:

RCP Leakage
This is assumed to be at a constant rate of 25 gpm/RCP for a total of 75 gpm starting 10 minutes into the transient. No critical flow was modeled for this leak because the flow was assumed constant for the duration of the event.

RCS Leakage (Other than RCP seal leakage)
This is assumed as 25 gpm at time zero and allowed to vary with pressure. At the end of 8 hrs, this leakage is predicted to be approximately 9 gpm. The RCS remains subcooled throughout the event except in the upper head and therefore, the discharge flow is maintained as single phase and never goes two-phase. The Dynamic Slip option in RETRAN was selected for all junctions in the model, including the leak junction but, since the fluid remains subcooled in the cold leg, it has no impact on the predicted leak flow rate. The Extended Henry Critical Flow Model is used to predict the leak flow rate.

d. Identify the primary steam condensation correlation employed in RETRAN, and provide a justification for the applicability of the correlation to condensation in the small vertical tubes of the SG.

There is no condensation predicted to occur in the SGs (primary side) during the Cooldown SBO scenario analyzed.

e. Discuss whether the SGs drain during the small LOCA event described above and how the condensation correlation is applied when two-phase is flowing through the active tube region.

The hot legs remain subcooled for the duration of the event analyzed and natural circulation is not lost. SG tubes do not drain and thus no condensation is predicted to occur during the Cooldown SBO scenario analyzed.

f. Since the transfer of stored energy in the metal walls to the coolant was not modeled, the calculated cooldown times to a RCS temperature of 377 °F may be too rapid. Typically, metal wall heat addition can contribute as much as the equivalent of 20 to 30 percent of the decay heat as additional heat deposited into the RCS for small breaks in the RCS. The 10 percent uncertainty added to the decay heat curve does not appear to capture wall heat effects. Describe how the omission of wall heat impacts the conclusions of the analysis. Include the effect of increasing the multiplier on decay heat to account for the lack of the wall heat sources or include metal wall heat effects into the model.

As long as the heat sink is maintained, higher decay heat would only result in a higher demand in ADV flow to maintain the 25 °F/hr imposed RCS cooldown rate with no significant changes to the overall RCS response. Based on this, metal heat from vessel and structures was not modeled.

Metal heat with a more elaborate representation of the vessel upper head volume allowing phase separation and non equilibrium effects would provide a more accurate prediction of the pressure and dynamics of the region. However, the overall RCS response in terms of the potential challenge to core cooling is not expected to be significantly affected by this modeling change.

g. ***Describe the atmospheric dump valve area during the cooldown and indicate whether the cooldown rate becomes limited by the valve position before Residual Heat Removal (RHR) entry conditions are achieved.***

The flow area of the ADVs is changed throughout the transient to maintain a constant 25 °F/hr cooldown. At no time during the cooldown, does the valve position reach the full open position. It remains well below the full open position throughout the event.

h. ***A constant reactor coolant pump (RCP) seal leakage of 25 gallons per minute (gpm) per pump is assumed, while the break is 25 gpm and varies with pressure. Justify the assumption that the RCP seal leakage is constant and indicate why a critical flow model was not used to calculate the leakage. Indicate how the break flow was determined as a function of pressure and break enthalpy.***

The assumed constant 25 gpm/RCP seal leakage flow is intended to conservatively envelope RCP data provided by Westinghouse in WCAP-10541, Revision 2 (*Reactor Coolant Pump Seal Performance Following a Loss of All AC Power*). The RCP seal leakage flow rate is thus assumed independent of pressure. However, the thermodynamic properties of the fluid are based on the RCS conditions at the point of the leak.

The RCS break flow of 25 gpm is modeled with a normal RETRAN junction between one of the cold leg volumes in the model and the containment volume. This is assumed as 25 gpm at time zero and allowed to vary with pressure. At the end of 8 hrs, this leakage is predicted to be approximately 9 gpm. The RCS remains subcooled throughout the event except in the upper head and therefore, the discharge flow is maintained as single phase and never goes two-phase. The Dynamic Slip option in RETRAN was selected for all junctions in the model, including the leak junction but, since the fluid remains subcooled in the cold leg, it has no impact on the predicted leak flow rate. The Extended Henry Critical Flow Model is used to predict the leak flow rate.

i. ***Identify what volumes employed the slip option. Was the slip option used in the steam generator primary active tube region? What code benchmarks were performed to justify the use of slip? Demonstrate that RETRAN can predict phase separation in components. Also, explain whether the slip option maximizes the size of the condensing surface when steam develops in the top of the active tube region.***

The slip option in RETRAN was activated for all RCS junctions in the model in the scenario analyzed, including those in the SGs. Since the RCS remains subcooled throughout the transient, (except for voids in the vessel upper head), and the SG primary active tube region remains subcooled throughout the transient, the option does not result in any significant impact. Therefore, benchmarks of this code capability are not considered necessary for this application.

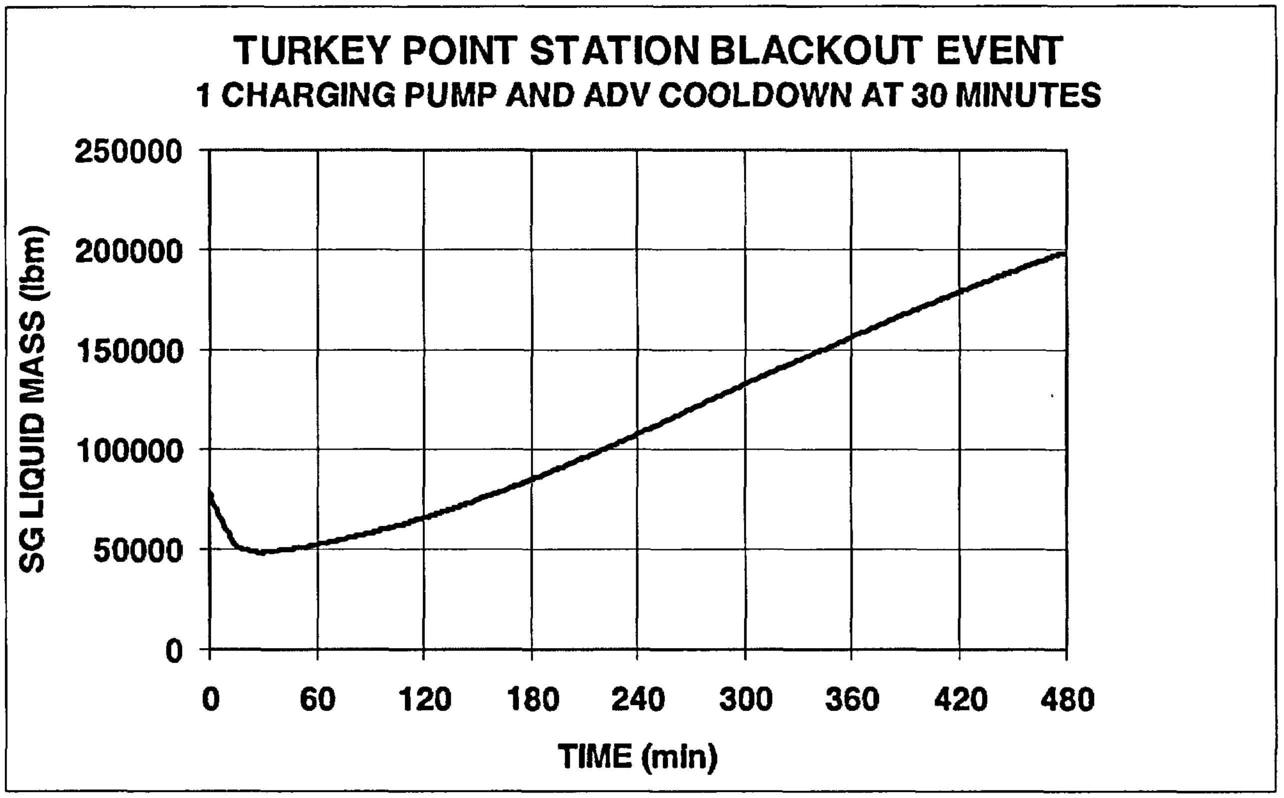
2. *Only 78 gpm per steam generator was assumed for emergency feed flow. Since emergency feedwater was not initiated for 30 minutes, the liquid inventory would be rapidly exhausted during the first 30 minutes of the event. Given these conditions, discuss whether the two-phase level on the secondary side drops below the top of the tubes exposing the top portion of the tubes to steam. If so, describe whether the primary to secondary temperature difference will increase, as well as RCS pressure. Additionally, provide the secondary two-phase level versus time. Note, that if there is the potential for the secondary two-phase level to recede below the top of the tubes during the early portion of the event, a single cell representation may not be appropriate. Justification for the secondary model, including level swell benchmarking will be needed. Describe the benchmarks used to justify the secondary, single cell model.*

The SGs start from a nominal inventory when they are isolated at time zero following the initiating reactor trip/turbine trip. They remain isolated until the three steam driven auxiliary feedwater pumps automatically start on a feedwater pump breaker opening signal at the beginning of the event. Any single pump is designed to supply the feedwater requirements of either Unit. A conservative delay of 15 minutes to start delivery of the auxiliary feedwater flow to the SGs has been assumed in the analysis. During the time the SGs remain isolated they only lose inventory through the cycling of the MSSVs which relieve core decay heat. The cycling of the MSSVs is terminated at 30 minutes for the Cooldown SBO scenario, when the ADVs open. For the Hot Standby SBO scenario, the cycling continues for the duration of the event. The steam dump to condenser is not operable for SBO scenarios. The predicted SG initial mass inventory loss during the MSSV cycling period is approximately 30% at 10 minutes and 40% at 15 minutes into the event, before the auxiliary feedwater is actuated (see Figure 1). During a SBO event, only one steam driven auxiliary feedwater pump is necessary to deliver approximately 78 gpm of water to the entrance of each SG in both Units. The flow assumed in the two SBO analyses performed here is conservatively assumed as that from one pump only or 78 gpm/SG. The initial inventory loss and potential uncovering of the tubes lasts only for a short period and is not expected to be widespread. It occurs during the first 15 minutes of the event before auxiliary feedwater is started. This short term initial inventory loss and potential uncovering of the tubes occurs well before voids start forming in the upper head after the RCS cooldown is started at 30 minutes.

The RETRAN model used to analyze the two SBO scenarios presented has a single node representation of the secondary side of the SGs. A multinode SG secondary side representation would provide a more accurate prediction of the secondary response. However, it is not anticipated that it would impact the results of the analysis in terms of the potential challenge to core cooling. This is because, given the minimal inventory loss from the cycling of the MSSVs discussed above and its early recovery, enough inventory will remain in the SGs during the major portion of the transient to preclude a deterioration of heat transfer that would require a multinode type of representation. Therefore, the single node SG representation is considered adequate to represent the secondary side of the SGs for this application.

Based on the above discussions, the single node secondary side SG model is considered adequate to predict the RCS response for the two SBO scenarios analyzed and no benchmarks of the model are considered necessary.

FIGURE 1


TURKEY POINT STATION BLACKOUT EVENT
1 CHARGING PUMP AND ADV COOLDOWN AT 30 MINUTES
SG LIQUID MASS (lbm)
250000
200000
150000
100000
50000
0
0
60
120
180
240
300
360
420
480
TIME (min)

3. *A single volume is used for the upper head. Because an equilibrium model was employed, this region fills completely at 375 minutes, which does not appear to be correct. Once the SGs refill with liquid and single phase natural circulation is re-established, a bubble will remain in the upper head region (unless the RCPs are re-started or the head vent is used). Thus, following refill, the upper head will become superheated with wall heat transfer from the steam controlling the degree of steam superheat. The use of the single volume to represent the upper head and the equilibrium model will artificially condense the steam in this region, enabling a complete and early refill. Discuss whether a bubble in the upper head will significantly delay the ability to cool down the RCS to RHR entry conditions within the 8-hour period. A bubble in the upper head would cause the pressurizer level to decrease during charging pump operations. Given these considerations, discuss whether entry into shutdown cooling will be achieved before the condensate storage tank is exhausted. Discuss whether entry into shutdown cooling will be delayed if a fill-and-drain method is used and metal wall heat is taken into account. Include the capacity of the condensate storage tank and identify the time to exhaust this supply during the cooldown.*

Allowing phase separation in the region and modeling it as a non-equilibrium volume with metal heat from the vessel and structures would provide a more accurate response of the dynamics of the region. In particular, heat transfer from the metal to both the liquid and vapor phases would be predicted along with condensation of vapor onto the interface. This would have an effect on the depressurization rate and the time of refilling the region. However, given the fact that the heat sink is maintained through the continuous addition of auxiliary feedwater for the duration of the 8-hour event, this effect is not expected to challenge the overall conclusions of the analysis in terms of potential core uncovery.

Each unit's Condensate Storage Tank (CST) contains sufficient inventory to maintain the unit at hot standby for 15 hours and then cooled down to below 350 °F in 4 hours. With this requirement and the conditions of the SBO scenario analyzed herein, it is unlikely that the CSTs would have been depleted during the 8 hour duration of the SBO event.

Given the relatively small RCS cooldown rate of 25 °F/hr, intended to prevent excessive upper head voiding, the homogeneous representation of the vessel upper head in the RETRAN model is considered appropriate for this application.

Aspects related to the capability to collapse the vessel upper head bubble, if still present at 8 hours when the shutdown cooling phase starts, are beyond the assumptions of the SBO analysis because at the end of the 8-hour period, the SBO event is assumed to terminate. The RETRAN analysis concluded that during the 8-hour SBO period, the aspects related to the dynamics of the upper head bubble will not interfere with the ability to maintain the core cooled, provided the heat sink is maintained, as demonstrated above.

4. ***In the event full charging is used or a high pressure safety injection pump initiates, which will fill the pressurizer with hot water early in the sequence, discuss how the RCS pressure will be reduced to enter shutdown cooling once the entry temperature is achieved. With hot water trapped in the pressurizer, pressurizer sprays or a fill-and-drain method would be needed to reduce pressurizer pressure. Please describe the method employed to cool the pressurizer. Determine whether there is sufficient condensate supply to accommodate an extended cooldown if needed.***

Pressurizer level of the SBO unit will drop as a result of the reactor trip at the beginning of the event and is expected to recover slowly (see response to Question 6), depending on RCS leakage rate, when the SBO cross-tie is established. Then, emergency operating procedures direct that pressurizer level be maintained between 29-50% and also that RCS conditions be maintained in hot standby conditions. If pressurizer pressure control cannot be maintained with pressurizer heaters, auxiliary spray (from charging) and normal letdown, the emergency operating procedures direct that the operator may utilize pressurizer heaters and one PORV.

The CST capacity is adequate for 15 hours at steady state hot standby conditions, and a 4 hour cooldown to shutdown cooling entry conditions. The 15-hour CST capacity exceeds the 8 hour station blackout duration.

5. *Explain the basis for assuming 72 gpm charging flow.*

The charging pump In-Service Test Program (IST) operability criterion for flow rate is bounded by the 72 gpm value assumed in the RETRAN analysis. Normal range for IST testing is approximately 75 to 80 gpm. Therefore, the assumption for a charging pump flow rate of 72 gpm is conservatively lower than actual or expected values.

6. *In Attachment 3, page 1 of 2, the pressurizer level is shown to increase after 120 minutes with constant charging flow less than the constant RCP leakage during the event (72 gpm in vs 125 gpm out). Please explain the pressurizer level behavior. In this hot standby condition, the liquid level in the vessel and loops would drain down to the break elevation. To preclude uncovery, the injection rate would thereafter need to exceed the boil-off rate in the system to prevent uncovery, and this boil-off rate would depend on the decay heat level. Please demonstrate that when the two-phase level in the RCS decreases to the break elevation, sufficient time has elapsed to enable the 72 gpm injection rate to exceed the boil-off in the RCS. Also demonstrate that the lack of a wall heat model, which will increase the RCS boil-off rate, does not impose additional injection requirements during the cooldown.*

For the Hot Standby SBO scenario the charging flow is capable of slowly refilling the system from the time it is started, at 30 minutes, as the following mass balance indicates. The pressurizer never drains and the level shows a small increasing trend after charging is started.

	TIME (minutes)		
	32	248	480
RCS Leakage Flow, lbm/s (gpm)	-2.09 lbm/s (20.2 gpm)	-1.98 lbm/s (19.1 gpm)	-1.95 lbm/s (18.9 gpm)
Total RCP Leakage Flow, lbm/s (gpm)	-7.76 lbm/s (75 gpm)	-7.75 lbm/s (75 gpm)	-7.75 lbm/s (75 gpm)
Charging Flow, lbm/s (gpm)	+9.97 lbm/s (72 gpm)	+9.97 lbm/s (72 gpm)	+9.97 lbm/s (72 gpm)
Net Mass Flow, lbm/s	**+0.12 lbm/s**	**+0.24 lbm/s**	**+0.27 lbm/s**

For the Hot Standby SBO scenario, RCS voiding is not predicted. Therefore, break uncovery concerns do not apply to this scenario.

7. ***Explain why the RCS pressure does not remain at the power operated relief valve (PORV) setpoint (until auxiliary feedwater is initiated at 15 minutes) after it opens at 80 seconds. If the PORV sticks open, discuss the time available until the core uncovers and what other injection sources are available to preclude core uncovery.***

The PORV opening predicted in the analysis is just a transitory opening, which lasts about 2 seconds. It results from the sudden loss of heat sink when the turbine trips following reactor trip at the beginning of the event and before MSSV cycling can relieve the core decay heat. With core decay heat as the only RCS energy source, the pressurizer pressure will quickly decrease below the PORV setpoint after reactor trip.

A stuck open PORV is not considered credible because it would constitute a "second" single failure (beyond the three EDG failures already assumed) and, typically is not considered a part of the SBO scenario.

8. ***The Tagami/Uchida correlations are typically used for minimum pressure evaluations for LOCA containment back pressure boundary conditions. The evaluation implies the containment model represents a bounding or maximum pressure determination. If a maximum pressure/ temperature is to be determined, containment wall condensation and other heat removal capabilities would need to be minimized. Explain how the results of these containment calculations are used.***

The Hot Standby SBO scenario was analyzed without the forced RCS cooldown, thus maintaining the RCS at hot standby conditions. The main purpose of this analysis was to assess the containment capability to withstand the consequences of a continuous hot RCS leakage for 8 hours with only passive heat removal available (no emergency containment fan coolers and no containment spray). The containment model used in the analysis is approximated with a single volume/compartment (with phase separation allowed) simulating the containment free air volume. The initial conditions are set conservatively to be maximum expected normal operating conditions of 15 psia and 130 °F. The RCS leakage flows are modeled with separate junctions. Each leakage junction is attached from the desired local RCS piping loop volumes to the containment volume. The containment passive heat sinks were modeled in detail.

The Tagami-Uchida correlation, with appropriate use of multipliers, can be used for containment backpressure in LOCA PCT calculations and can also be used for containment peak pressure and peak temperature design calculations, and has been approved by the NRC for both applications. The correlation is composed of two distinct parts intended specifically for modeling large break LOCA containment response. The Tagami heat transfer correlation is applicable during the initial blowdown time period when turbulent steam flow conditions are expected within the containment building. The Tagami heat transfer correlation results in larger heat transfer coefficients than the Uchida correlation, as warranted by turbulent flow conditions. The Tagami heat transfer correlation is applied from the beginning of blowdown, until peak pressure is reached inside containment. After the time of peak pressure, the heat transfer correlation is reduced gradually until the end of blowdown occurs. After blowdown ends, a non-turbulent air/steam mixture is expected inside containment and the Uchida heat transfer correlation is used, until the end time of the analysis. This correlation yields lower condensing heat transfer coefficients than the Tagami correlation.

The containment response to the SBO event analyzed for Turkey Point does not involve the type of phenomena associated with large break scenarios. It involves small leakage flows to the containment (from the RCPs and from the RCS), which are expected to flash into steam and potentially pressurize the containment. As per NUREG-0800 Section 6.2.1.5 Rev. 2, a multiplier of 1.2 on the Uchida correlation is recommended to predict containment backpressure in LOCA PCT calculations. The use of the Uchida condensing heat transfer correlation with a multiplier of 1.0 throughout the entire event is considered adequate to predict the containment response during the analyzed SBO event.

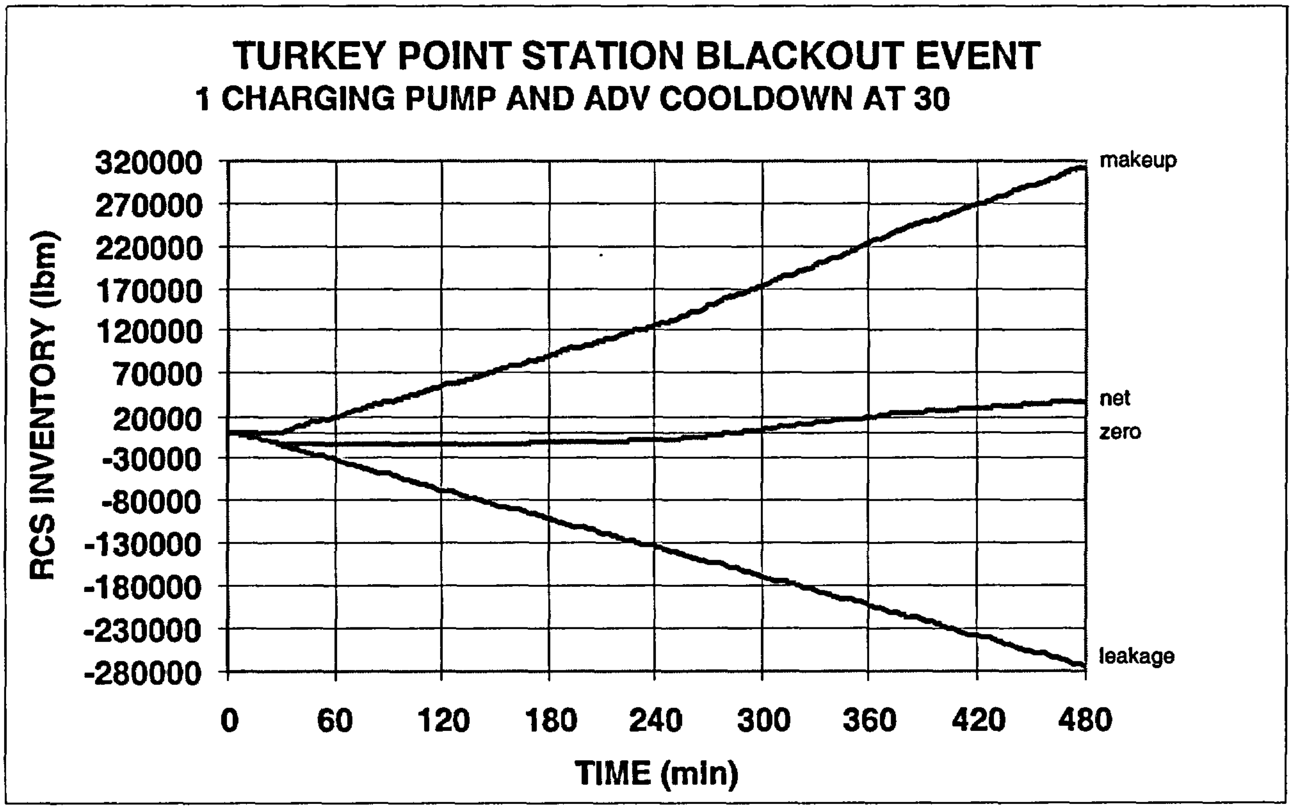
The results of the analysis show the containment pressure remaining below 22 psia for the duration of the 8-hour SBO event, which is well below the design basis limit of 49.9 psig. Therefore, it is concluded that the most limiting SBO event (the Hot Standby SBO), in terms of containment response, will not challenge containment integrity. Given the margin predicted to the peak pressure, sensitivity analyses on the containment modeling are not considered necessary.

9. ***The constant RCP leakage of 100 gpm is approximately 12 pound per second (lbs/sec) at 367 psia and 380 °F, the conditions at the end of the cooldown. Since the constant charging flow of 72 gpm at 100 °F is 9.9 lbs/sec, the injection rate during the entire 8-hour event does not exceed the loss through the break (except when the accumulators inject). At some point, the injection would need to be increased to refill the system with liquid. Explain how inventory is controlled during the long term.***

The Cooldown SBO scenario analyzed has a constant RCP total leakage of 75 gpm and a pressure dependent RCS leakage that starts at 25 gpm. As the RCS continues to depressurize throughout the transient, the RCS leakage continues to decrease and at the end of the 8-hour period is only 9.1 gpm (1.11 lbm/s). Figure 2 shows the total liquid mass added to the system, the total liquid mass leaked out of the system and its difference or net mass inventory. The slope of the net mass inventory is always positive after charging starts at 30 minutes. For the portion of the event before the accumulators start discharging at 255 minutes, the charging mass flow rate is slightly higher than the total leakage mass flow rate. For the portion of the event after 255 minutes, the accumulators more than make up for any imbalance between charging flow and total leakage flow.

Figure 2 clearly shows a change of the slope of the net mass inventory when the accumulators start refilling the system at 255 minutes. At the end of the 8-hour cooldown SBO event analyzed, the accumulators still retain more than 70% of their initial inventory. Therefore, there are no long-term concerns with respect to the capability of the ECCS to refill the system and maintain core cooling.

FIGURE 2


TURKEY POINT STATION BLACKOUT EVENT
1 CHARGING PUMP AND ADV COOLDOWN AT 30
RCS INVENTORY (lbm)
320000
270000
220000
170000
120000
70000
20000
-30000
-80000
-130000
-180000
-230000
-280000
0
60
120
180
240
300
360
420
480
TIME (min)
makeup
net
zero
leakage