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Subject: Response to Request for Additional Information Related to Topical Report NTH-TR-01, RETRAN Model Qualification - St. Lucie Plant Unit Nos. 1 and 2 and Turkey Point Plant Unit Nos. 3 and 4 (TAC Nos. M75082, M75083, M75084 and M75085)

On June 18, 1992, a conference call was held with the NRC concerning Florida Power & Light Company's (FPL) report, NTH-TR-01, "RETRAN Model Qualification - Decrease in Heat Removal by the Secondary System". The purpose of this letter is to provide FPL's response to the request for additional information resulting from the call (attached).

If additional information is required on this topic, please contact us.

Very truly yours,

W.H. Bohlke
Vice President
Nuclear Engineering and Licensing

WHB/vmg

Attachment

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
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QUESTIONS # 1 AND 2

QUESTION # 1: Qualify and discuss Single Node SG model performance for applicable transients (Turkey Point and St. Lucie).

QUESTION # 2: Evaluate nodalization sensitivities regarding multi-node SG modeling.

1.0 BACKGROUND AND SUMMARY OF RESULTS

The FPL RETRAN Methodology of Reference 1 proposes the use of a Single Node Steam Generator (SNSG) model for scenarios where monitoring of steam generator level is not required. The SNSG is the model of choice throughout the industry for analysis of this type of event (Reference 2).

The FPL Methodology also proposes the use of a Multi-Node Steam Generator (MNSG) model to analyze transients that require steam generator level predictions such as the Turkey Point Loss of AC Power transient. In addition to providing level prediction capability, it has been demonstrated (Reference 2) that a MNSG representation produces more conservative results for this analysis.

In response to NRC Questions from Reference 3, FPL has performed steam generator nodalization studies to evaluate the modeling approaches proposed in Reference 1. The following are the major conclusions.

- The current MNSG model proposed in Reference 1 is acceptable for analyses of mild transients. For this discussion a mild transient is one where the steam generator secondary mass does not approach dryout.

- The current MNSG model described in Reference 1 needs to be modified to properly model the plant behavior during the Turkey Point Loss of AC Power transient. The nature of this model change is described in Section 4.0.

- The SNSG representation to analyze the remaining events in the "Loss of Secondary Heat Removal" category (Loss of Load type events) is acceptable.

2.0 PROCESS FOLLOWED TO EVALUATE STEAM GENERATOR MODELING

The steps FPL followed to assess the steam generator modeling in Reference 1 are summarized below.

- Benchmark an actual plant event using the current MNSG nodalization (Reference 1) and relevant code modeling options.
- Evaluate the impact of increasing and decreasing the number of nodes on the predicted system response.
- Apply the lessons learned from the above evaluation to improve the Turkey Point Loss of AC Power analysis of Reference 1.
- Justify the use of a SNSG modeling representation to analyze the Loss of Load events in Reference 1.

3.0 STEAM GENERATOR MODELING ASSESSMENT

3.1 Plant Event Benchmark

The event selected for the steam generator nodalization studies was initiated by the failure of an underfrequency relay at Turkey Point Unit 4 on April 9, 1990 (References 4 and 5). This failure resulted in the trips of the B and C Reactor Coolant Pumps, the reactor and the turbine and initiated a mild cooldown event.

3.2 Assessment of Code Modeling Options on Benchmark

The current Turkey Point MNSG RETRAN model (Figure 1) was used to obtain the best possible benchmark with the plant event. This benchmark was the basis for the steam generator nodalization studies. The following two RETRAN code options (Reference 6) were exercised in this benchmark analysis.

- Temperature Transport Delay Time
- Slip

The Temperature Transport Delay option provides a more detailed representation of the movement of fluids at different temperatures. Its use resulted in an improved prediction of the plant event.

The Slip option provides separate accounting of the phenomena associated with the vapor and liquid phases in regions where the two phases are present. Its use did not affect the prediction of the plant event and therefore was not retained. However, in situations where severe voiding occurs, as in the

analysis of the Loss of AC transient, this option should be included.

3.3 Impact of More Nodes in the MNSG Model

The two regions in the steam generator model (Figure 1) most likely to be impacted by a more detailed nodalization are the downcomer and the tube bundle regions. In particular, the lower tube bundle region is where the colder feedwater/auxiliary feedwater begins absorbing heat from the primary side. A finer nodalization will allow a better representation of the heat transfer process taking place in this region. A more detailed nodalization of the downcomer region has been considered to be of lesser impact, especially if the Temperature Transport Delay code option is used.

Based on the above arguments, a new MNSG model was prepared in which each of the lower two tube bundle volumes and heat conductors was split into two equal volumes and heat conductors, respectively. This corresponds to volumes 110 and 115 and conductors 4 and 9 for the Single Loop steam generator model (see Figure 1).

The use of this finer nodalization had an insignificant impact on the benchmark predictions for this transient. This is due to the fact that the steam generator inventory is not severely depleted during the plant event and therefore the heat transfer in the lower tube bundle is not much affected.

This modeling approach, although not important for the plant event, needs to be evaluated in situations where the inventory is severely depleted such as the Loss of AC Power transient.

3.4 Impact of Fewer Nodes in the MNSG Model

Two different approaches have been pursued in the area of simplifying or reducing the number of nodes in the MNSG model of Figure 1. They are briefly discussed below.

<u>Conversion of the Steam Generator Separator Volume into a Regular Volume</u>

The basis for this change is that by eliminating phase separation in the volume that represents the actual separator (volumes 130 and 230 in Figure 1), the typical uncertainty associated with separator modeling is removed.

One Stack Tube Bundle

The two parallel volume stacks in the tube bundle of the current MNSG model (Figure 1) have been combined into a single stack. Although the two-stack approach is justifiable in terms of the little mixing between the two sides of the tube bundle (Reference 7), this sensitivity study has been selected to investigate any possible differences between the two approaches.

Neither of these two changes resulted in an improvement in the model's ability to predict plant data.

3.5 Impact of Using a Single Node Steam Generator Model

The plant event has also been analyzed with the SNSG model. A SNSG model represents the limiting simplification with only one large shell side volume.

The SNSG prediction for the plant transient was very similar to that obtained using the MNSG model. This result confirms the adequacy of the SNSG representation to predict mild transients.

3.6 Conclusions from the Steam Generator Modeling Assessment

The steam generator nodalization studies show that increasing or decreasing the number of nodes in the current MNSG model does not improve the model's ability to predict plant responses to mild transients. For mild events such as the one benchmarked here both the MNSG and the SNSG models can provide good predictions.

FPL has implemented the lessons learned from this work to further improve the applicability of the current MNSG model for events such as the Turkey Point Loss of AC event where a severe loss of inventory occurs. As part of this effort, several of the modeling approaches which did not impact the plant benchmark, have been identified as important for the analysis of this event (see Section 4).

4.0 REEVALUATION OF THE LOSS OF AC POWER TRANSIENT

The Turkey Point Loss of AC Power transient included in Reference 1 has been reanalyzed with the following three modeling techniques evaluated during the plant event benchmark analysis.

- Slip
- More nodes in the steam generator lower tube bundle region
- Temperature Transport Delay option

The first two changes provide an improved distribution of the liquid mass in the steam generator and result in a more realistic prediction of the heat transfer and dryout time. Without these two options predicted dryout times are too early and heat transfer is too high.

The Temperature Transport Delay option allows a better modeling of temperature changes as they propagate as fronts throughout the system. The modeling of such fronts is of importance in situations where their propagation is slowed down by flow reductions.

Inclusion of these modifications in the Loss of AC Power analysis results in a calculation that is more conservative than the one presented in Reference 1 and is in closer agreement with the vendor analysis of this event (Reference 8). The majority of the input assumptions in both the FPL and the vendor analyses are the same (Reference 9). However, the analytical methods to simulate the event are different. The vendor methodology uses a single node steam generator model with an artificial representation of the heat transfer between primary and secondary to yield conservative results. The FPL methodology, as revised here, is based on the RETRAN code with an expanded multinode representation of the steam generator to better represent the fluid conditions in the lower tube bundle region. Comparisons between the vendor and the RETRAN results are shown in Figures 2 through 5 and Table 1. The results of the revised analysis do not change the conclusion from the original analysis (Reference 1), that the RCS can be successfully cooled with only one auxiliary feedwater pump without taking the pressurizer water solid.

5.0 JUSTIFICATION OF THE SINGLE NODE STEAM GENERATOR MODEL

In addition to the MNSG-based methodology for the Turkey Point Loss of AC Power transient, Reference 1 provides a methodology to analyze Loss of Load type of events. This methodology is based on a SNSG representation. Based on NRC accepted topical reports, published studies, and industry accepted licensing analysis practices, precedence has been established showing that the SNSG representation produces acceptable licensing calculations for the transients included in the category denoted as "Decrease in Heat Removal by the Secondary System" (Reference 2).

FPL has also evaluated the applicability of the St. Lucie and Turkey Point SNSG models for the analysis of Loss of Load type events, with the following conclusions:

- Both the St. Lucie and the Turkey Point SNSG models are based on the same modeling methodology. Therefore any conclusions on SNSG representation applies to both models.

- Sensitivity studies with a licensing Loss of Load type analysis confirmed that a MNSG representation, with smaller volumes in the shell side, predicts slightly higher system pressures than those predicted by a SNSG model.

- FPL has demonstrated, with a plant heatup event benchmark, that a SNSG representation overpredicts plant peak pressures and therefore provides a sufficiently conservative plant response envelope (Reference 10).

6.0 CONCLUSIONS

The capability of the current Turkey Point MNSG model to predict plant responses to mild transients has been confirmed through the nodalization studies presented in Section 3. The various nodalization changes investigated had no significant impact on plant responses predicted by the model thus justifying the use of the current MNSG model for mild events. However, more severe type events, such as the Turkey Point Loss of AC Power, require enhanced modeling to better account for the liquid mass in the lower tube bundle. The analysis of this event from Reference 1 has been supplanted by the analysis described in this response which includes improved modeling features and produces a more realistic and conservative response.

The SNSG representation in Reference 1 has been reevaluated and reconfirmed as an acceptable model for the analysis of Loss of Load type transients.

7.0 REFERENCES

1. FPL letter L-89-326, "Turkey Point Units 3 & 4 Docket Nos. 50-250 and 50-251 - St. Lucie Units 1 and 2 Docket Nos. 50-335 and 50-389 Report NTH-TR-01, RETRAN MODEL QUALIFICATION", dated October 12, 1989.

2. Answer to General Approach Question # 1 in Reference 9.

3. Telephone conference of June 18, 1992 between J. Norris from NRC, Dr. H. Komoriya from ITS. and M. Dryden et al., from FPL.

4. Turkey Point Nuclear Plant Post Trip Review (PTR) Restart Report # 4-90-01, Unit 4, Date: 4/9/90, Title: Reactor Trip Caused by U.F. Relay 4B2 Failure. Trip Evaluation Followup Report ERT 90-005.

5. Turkey Point Simulator Certification Test Procedure, MRC-008, Title: Loss of B and C Reactor Coolant Pumps at 100% Power, Date: 12/5/90.

6. RETRAN-02 (MOD004) A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems, EPRI NP-1850-CCM-A, Project 889-3, November 1988.

7. FPL letter L-92-152, "Response to Request for Additional Information Related to Topical Report NTH-TR-01, RETRAN Model Qualification - St. Lucie Plant Unit Nos. 1 & 2 and Turkey Point Plant Unit Nos. 3 & 4 (TAC Nos. 75082, 75083, 75084, 75085), dated May 19, 1992.

8. Turkey Point Units 3 & 4 FSAR, "Loss of Non-Emergency A-C Power to the Plant Auxiliaries" Analysis, Section 14.1.12, Rev. 9.

9. FPL letter L-91-108, "Response to Request for Additional Information Related to Topical Report NTH-TR-01, RETRAN Model Qualification - St. Lucie Plant Unit Nos. 1 & 2 and Turkey Point Plant Unit Nos. 3 & 4 (TAC Nos. 75082, 75083, 75084, 75085), dated May 2, 1991.

10. Analysis of the Turkey Point Unit 4, Loss of Inverter Event of June 20, 1985. Section 2.0, page 15 in Reference 1.

TABLE 1

TURKEY POINT LOSS OF AC POWER TRANSIENT RESULTS OF THE VENDOR AND REVISED RETRAN ANALYSES

EVENT	RETRAN VALUE	RETRAN TIME (S)	VENDOR VALUE	VENDOR TIME (S)
Reactor Trip		59		58
Auxiliary Feedwater Pump Starts		240		238
Auxiliary Feedwater Realigned		658		658
Cold Auxiliary Feedwater is Delivered to SGs After Hot Fluid in Piping is Purged		1105		1074
Peak Water Volume in Pressurizer (ft^3)	1134	2000	1240	3814

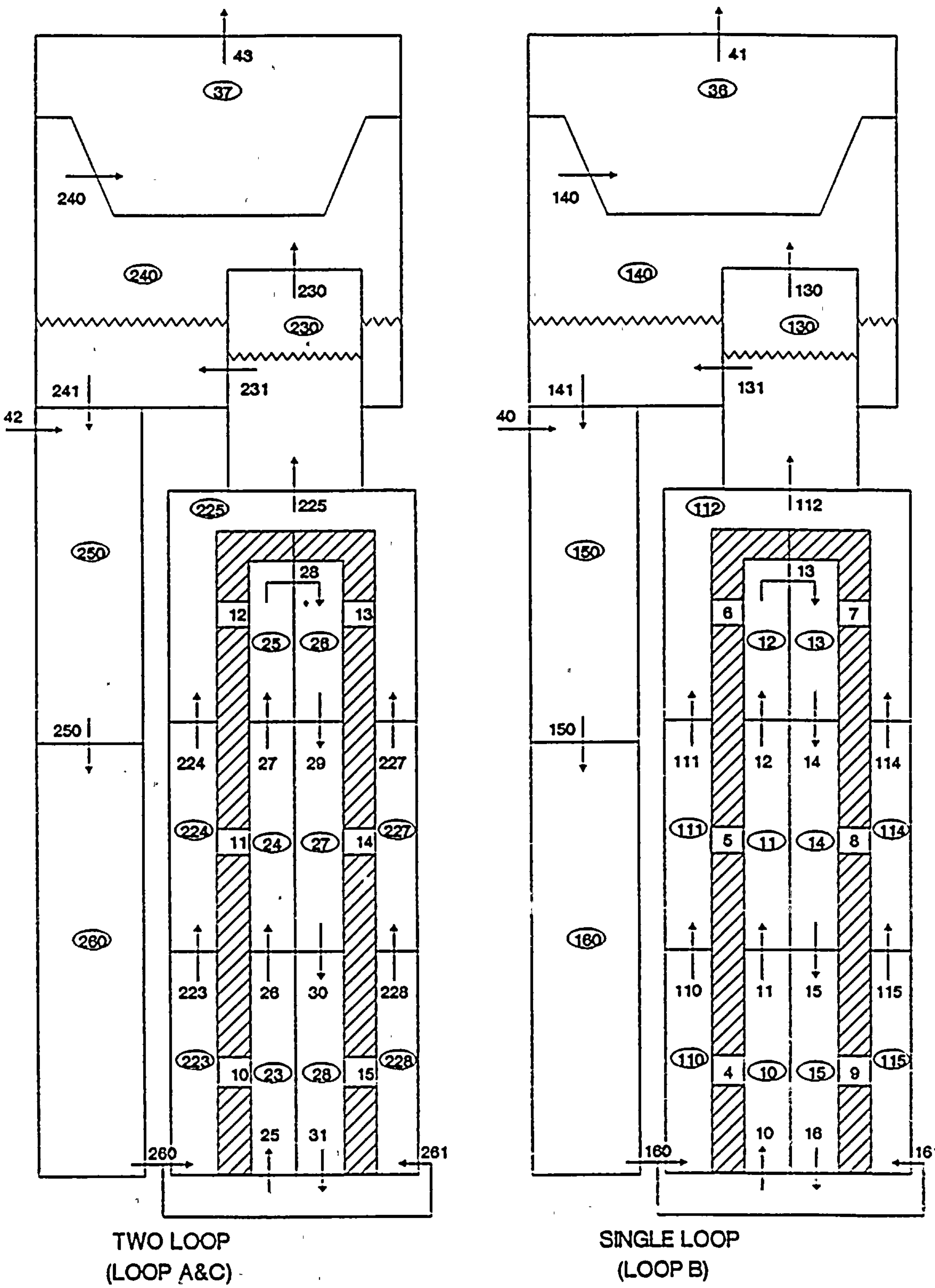
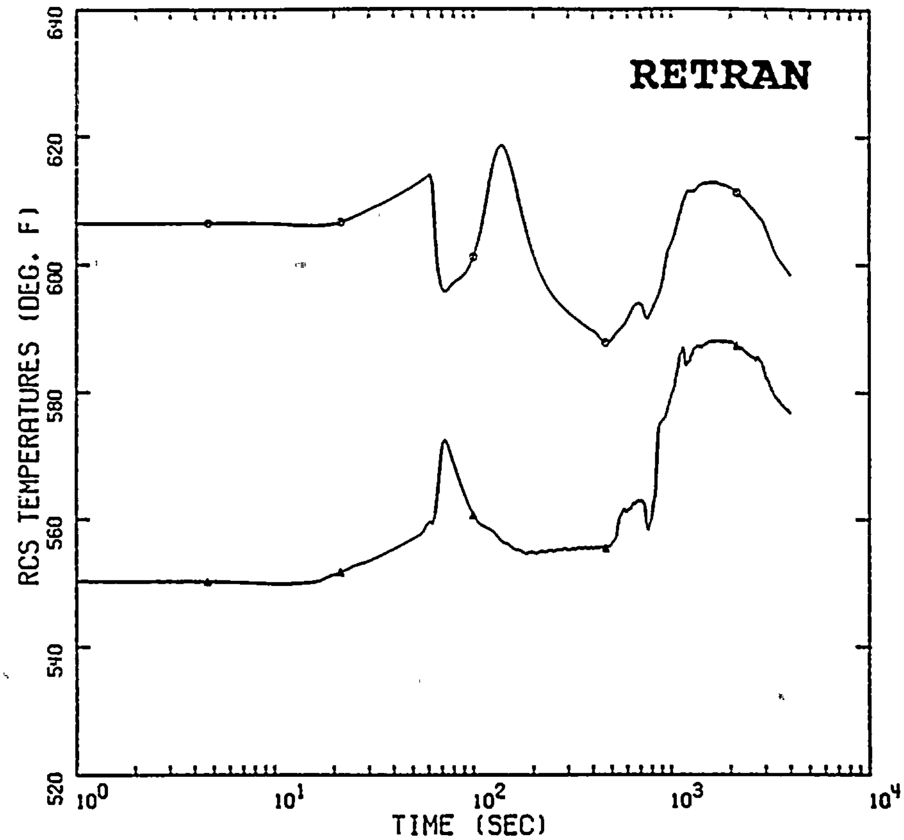


FIGURE 1. TURKEY POINT, RETRAN MULTINODE STEAM GENERATOR MODEL



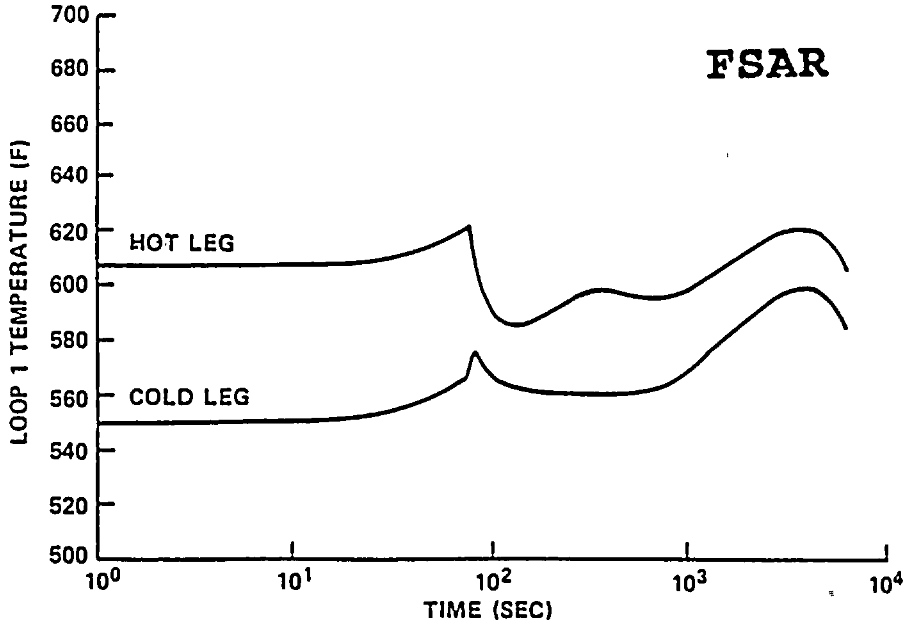
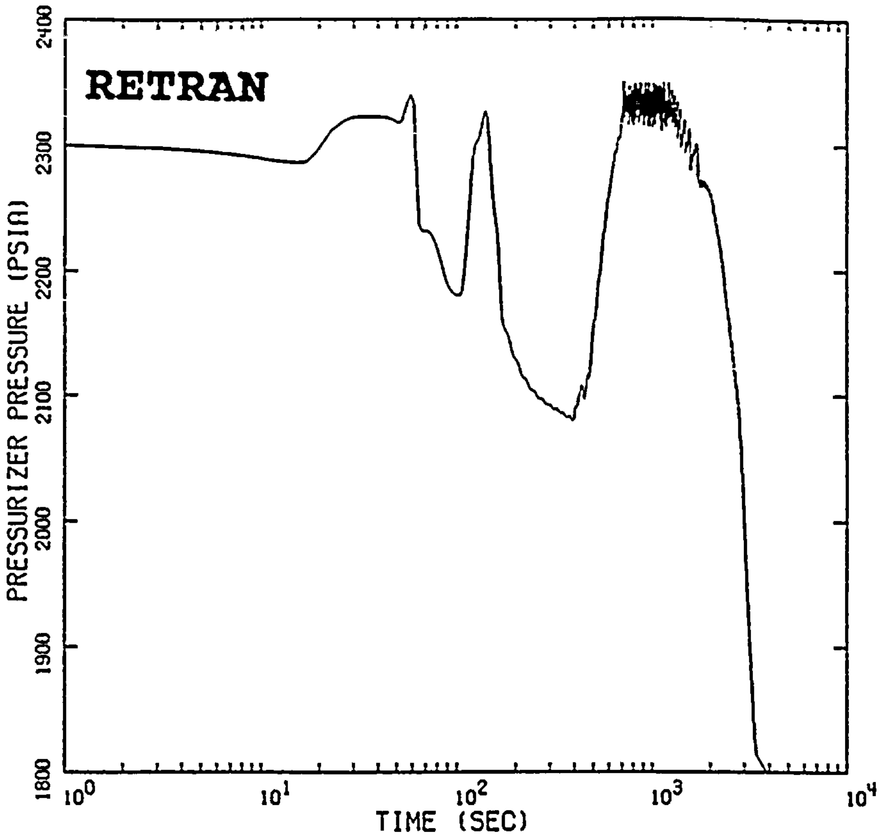


FIGURE 2. RCS TEMPERATURES



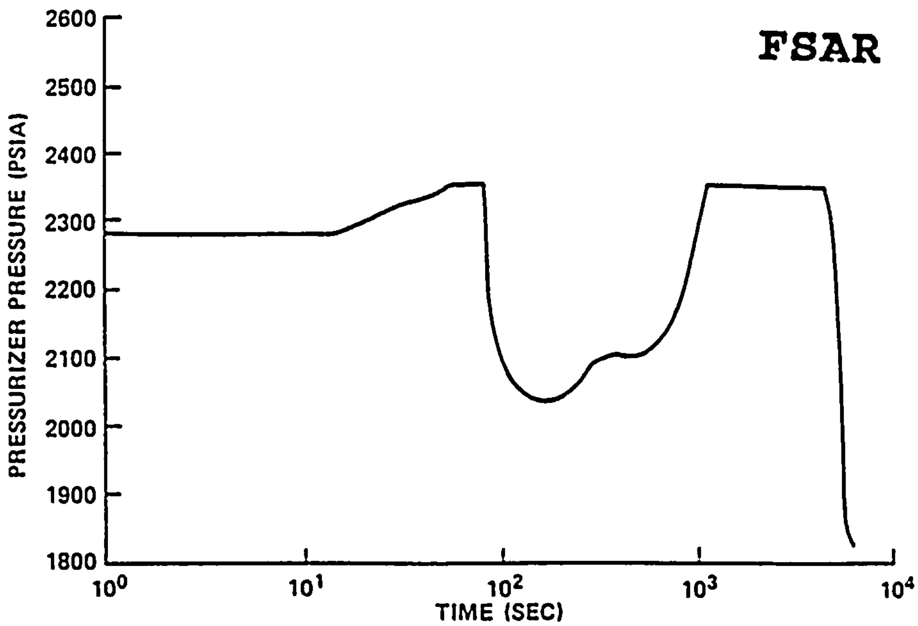
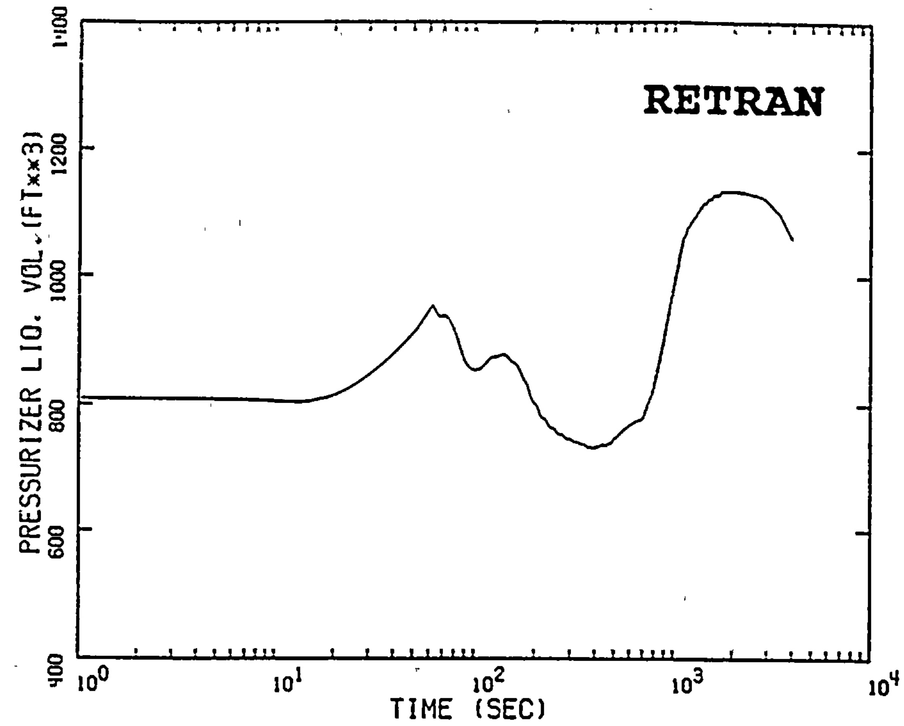


FIGURE 3. PRESSURIZER PRESSURE



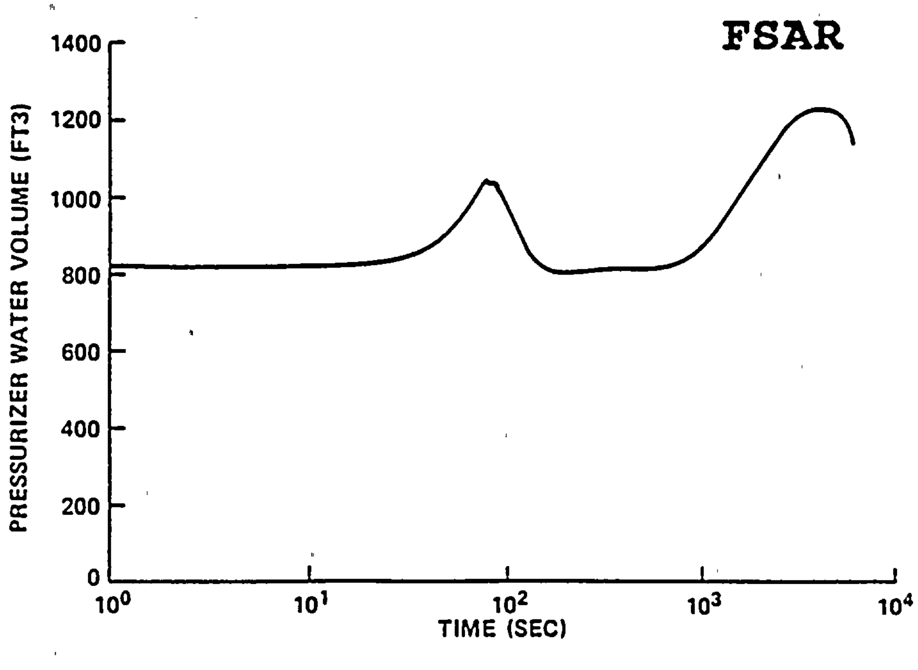


FIGURE 4. PRESSURIZER WATER VOLUME

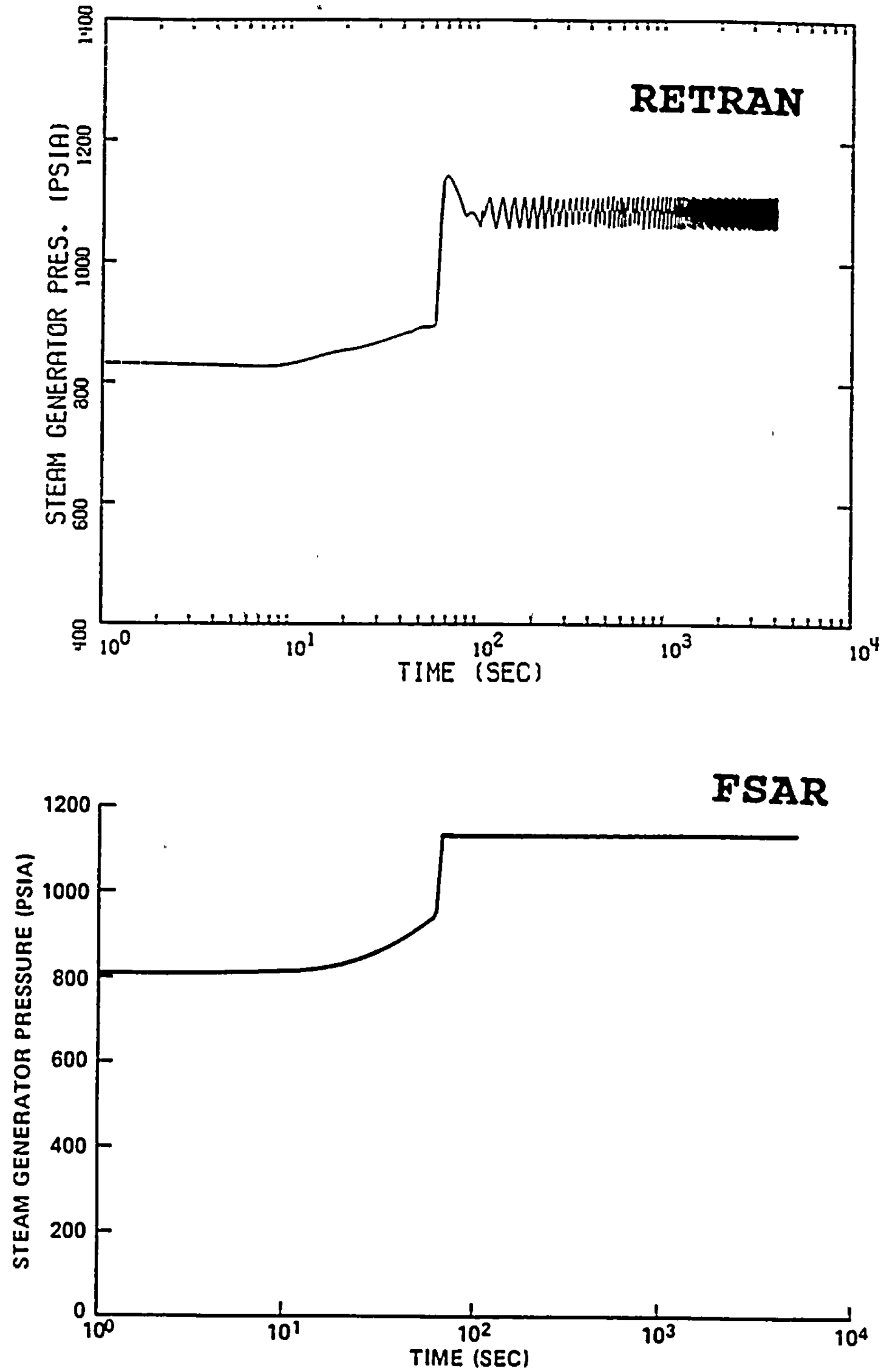


FIGURE 5. STEAM GENERATOR PRESSURE

QUESTION # 3

Amplify the FPL response to Question # 8 (Reference 3) and the additional FPL comments on this response provided during the conference call of June 18, 1992 (Reference 4).

FPL's goal in utilizing RETRAN is to provide a phenomenologically valid representation of the transients of interest with input values varying according to each analysis' purpose. FPL intends to use the methodology and modeling approaches discussed in References 1, 2 and 3 to:

a/ Provide best estimate analyses of actual or postulated transients; to respond to NRC or internal management questions concerning plant operation and/or

b/ Provide the technical bases for certain proposed license amendments for any of our nuclear units.

As noted above, input parameter values (e.g. MTC, initial pressure, RCS flow, etc.) would necessarily differ depending on the purpose of each analysis. For a NRC submittal in support of a license amendment, input values would be chosen based on Technical Specifications, operational experience, analytical studies or a combination of all three, to provide good assurance that a conservatively bounding result has been obtained. Many examples of this are presented in the Topical Report of Reference 1. Because the scope of this Topical Report is limited to plant heatup type events, FPL would only use the methodology presented in the Report to support plant license amendments where "Decrease in Heat Removal by the Secondary System" is the governing phenomenon. Examples of such applications include the evaluation of effects of: changes in the capacity or tolerance of the pressurizer and main steam safety valves, changes in instrumentation response times and changes in the reactor trip on turbine trip bypass power level setpoint. This list of applications is expected to grow as the capabilities of RETRAN-based applications become better known within FPL.

When analyzing transients to determine their impact on safety margin, the effects on potential for fuel centerline melt or violation of minimum DNB criteria must be considered as well as the potential for system overpressurization. By simple inspection of the sequence of events and evaluation of the major system parameters, it can be shown that this class of events (Decrease in Secondary Heat Removal) will produce fuel centerline temperatures and DNB results that are bounded by other categories of transients. A summary of the arguments to support this conclusion is presented below.

Fuel Centerline Melt

Fuel centerline melt can occur as a result of either globally or locally induced fuel power excursions. Inherent core physics characteristics and redundant plant protective trip functions prevent global power excursions leading to centerline melt from occurring. Fuel centerline melt can still occur as a result of localized reactivity or power distribution anomalies. Neither of these effects are present in the scenarios for the "Decrease in Heat Removal" class of transients. Local reactivity or power distribution perturbations are the main issue of concern in the Reactivity and Power Distribution Anomaly group of events. The changes in reactivity associated with the "Decrease in Heat Removal" transients are not localized; rather they are induced core wide by events initiated within the coolant and progress slowly. For comparison, power perturbations in Reactivity Anomaly type transients are typically very rapid and result in a mismatch between the power generated in the fuel and the power removed by the coolant that can potentially lead to fuel centerline melt. For the "Decrease in Heat Removal" type transients this power mismatch is not a concern because the fuel heatup follows that of the coolant and core metal structures.

Departure from Nuclear Boiling (DNB)

In order to challenge DNB limits during a transient there must be a substantial and rapid reduction in RCS flowrate, pressure or a significant and rapid increase in fuel rod heat flux. The rate of change of these parameters is important in determining how closely DNBR limits are approached prior to the protective actions of reactor trip functions. The transients that result in the greatest degradations of margin to DNB involve either a power distribution anomaly (e.g, full power operation with a dropped control rod) or a substantial and rapid reduction in reactor coolant flow while at power. None of the events included in the Topical Report of Reference 1 generate large enough changes in critical DNB variables to challenge the bounding values established by the limiting DNB transients. Because of this, the margin to DNB is not one of the key parameters for which Heatup type transients are analyzed.

References

1. FPL letter L-89-326, "Turkey Point Units 3 & 4 Docket Nos. 50-250 and 50-251 - St. Lucie Units 1 and 2 Docket Nos. 50-335 and 50-389 Report NTH-TR-01, RETRAN MODEL QUALIFICATION", dated October 12, 1989.

2. FPL letter L-91-108, "Response to Request for Additional Information Related to Topical Report NTH-TR-01, RETRAN Model Qualification - St. Lucie Plant Unit Nos. 1 & 2 and Turkey Point Plant Unit Nos. 3 & 4 (TAC Nos. 75082, 75083, 75084, 75085), dated May 2, 1991.

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4. Telephone conference of June 18, 1992 between J. Norris from NRC, Dr. H. Komoriya from ITS and M. Dryden et al., from FPL.

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