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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. 75082, 75083, 75084 and 75085)

On February 13, 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" (See attached References - Reference (1)). 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
Senior Resident Inspector, Turkey Point Plant, USNRC
Senior Resident Inspector, St. Lucie Plant, USNRC

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QUESTION # 1

QUESTION: Discuss and justify SG modeling: multi-node vs. single-node representation. Provide thorough discussion on the following topics:

- SG level computation and qualification through benchmark.
- Tube bundle modeling; stacked vs. parallel volumes.
- MNSG vs. SNSG in terms of primary peak pressure, PZR level and system temperature predictions (Figure 1-5 of Responses). Also discuss SG level computation for these analyses.
- Numerical convergence of MNSG/SNSG analyses.

FPL RESPONSE:

Steam Generator Water Level Computation

The steam generator water level in the FPL RETRAN multinode steam generator models is based on a functional relationship between downcomer volume and height above the tubesheet. This relationship was developed from detailed drawings and design data provided in the respective steam generator manuals. These drawings, in addition to general dimensions, provide the elevations of the level taps and other components relative to the tubesheet.

The performance of the level algorithms in the FPL RETRAN multinode steam generator models has been verified against plant data in the two benchmark analyses included in Reference (1). In addition to these two analyses, the St. Lucie multinode model was also benchmarked against a Loss of One Feedwater Pump plant event that occurred in June 1987. This event involved a turbine runback and a subsequent restart of the affected pump after 10 seconds. The Unit tripped on high pressurizer pressure but it came very close to tripping on low steam generator level. RETRAN successfully predicted this race between primary pressure and steam generator level and was within 1 second of the time of the reactor trip. This event, although used in the development of the RETRAN model was not included in Reference (1) because plant data for the event was not available; other than the sequence of events and conversations with plant staff.

The two best documented benchmarks for the RETRAN multinode steam generator models are the analyses included in Reference (1). In addition to these analyses, both multinode models have been used extensively, for the last three years, in analyses for the respective Simulator Certification Programs at St. Lucie and Turkey Point.

Parallel vs. Stacked Tube Bundles

The FPL multinode steam generators were modeled with two parallel stacks of fluid volumes representing the hot and cold sides of the generator. This was completed in order to better represent the physical phenomena in the tube bundle. Geometric separation between the two sides as well as the different velocity effects on both sides should be better captured with this type of representation. Cross flow between the two sides was ignored, based on information contained in Reference (3). According to Reference (3), flow redistribution does not occur until the region above the U-bend, below the separators. The flow split of 50% between the two sides, at steady state conditions, is also supported by information contained in Reference (3).

MNSG vs. SNSG Comparison Plots

The MNSG model is used only in the Turkey Point Loss of AC power analysis. All other licensing analyses included in Reference (1) utilize a SNSG representation. Comparison plots between SNSG and MNSG responses for the Loss of AC transient were discussed in Reference (2), (Question #1). The main conclusion in that reference is that the SNSG with instantaneous mixing of the cold auxiliary feedwater, over the entire generator volume, provides better heat removal than the MNSG. Consequently, the MNSG model was used to maximize the primary heatup. This analysis is further discussed in the answer to Question #7 of the current set of questions.

Numerical Convergence of MNSG/SNSG

In spite of being more difficult to initialize than the SNSG, the FPL MNSG models have been successfully initialized without having to relax any of the code default convergence criteria. In addition it should be noted that for any transient model, it is customary to check the stability of the steady state conditions with null transients.

<u>QUESTION # 2</u>

QUESTION: Use of the code developer's recommended values may or may not be appropriate for FPL's applications (Q.2). They need to be qualified.

FPL RESPONSE:

As concluded in Reference (2), (Question # 2), the values for the parameters of interest, selected for the heatup analyses in Reference (1), are adequate.

The analyses in Reference (1) are either based on conservative values for the parameters of interest (e.g. Heat Transfer Map or Inter-Region Heat Transfer Coefficient), or are insensitive to these parameters (e.g. Bubble Rise models).

As documented in Reference (2), (Question # 2), FPL has investigated the impact that modeling approaches or changes in the magnitude of relevant parameters have on the system peak pressure. The results of this investigation confirms that the above conclusion remains valid.

<u>QUESTION # 3</u>

QUESTION: **Discuss why the fuel thermal capacity was chosen to perform a sensitivity instead of fuel gap conductance. Justify the range of values used and its adequacy as surrogate for the gap conductance.**

FPL RESPONSE:

The Gap Conductances in the three RETRAN models (for St. Lucie 1, St. Lucie 2 and Turkey Point 3 & 4 Units) used in the transients of Reference (1) range between 400 and 800 Btu/hr/ft2-^{o}F. These values are about one order of magnitude lower than their corresponding best estimate values. Low gap conductance values increase the initial energy stored in the fuel and result in higher releases of energy into the coolant thus producing higher RCS pressures for the category of events of interest here.

The gap sensitivity studies included in Reference (2) were intended to maximize the initial stored energy in the fuel. They were performed by varying the UO2 Volumetric Heat Capacity directly instead of the Helium Thermal Conductivity or Gap Conductance. This was done to avoid having to further reduce the already low Gap Conductance values in the models. The conclusion stated in Reference (2) with respect to the impact of changing the initial stored energy is essentially the same regardless of what method is used. This has been confirmed with additional sensitivity studies in which the Helium Thermal Conductivity or Gap Conductance has been perturbed directly.

Based on the above, the conclusion reached in (Reference 2) is restated here. For the category of events analyzed in Reference (1), the Gap Conductance used in the RETRAN models for those analyses, which ranges between 400 and 800 Btu/hr/ft2-^{o}F, will be retained and will not be further reduced.

QUESTION # 4

QUESTION: Provide the reason(s) for FPL's use of much smaller initial RCS flow in the benchmark analyses.

FPL RESPONSE:

Measured RCS flow at the time of the respective events was not available for either benchmark RETRAN analyses. The flow values in Tables 1 and 2 of Reference (2), (Question #4), are reported for reference only and correspond to more recent plant measurements. Small variations in the RCS flow were not considered to have a significant impact on the results of the analyses.

The RETRAN models were initialized with the given plant T_{cold} for the event and the nominal power level. The RCS flows in RETRAN were iterated until the recorded T_{av} for the event was obtained. Uncertainties in the recorded T_{cold} and power level were not taken into consideration. If considered, the flow discrepancies could have been reduced. However, discrepancies on the order of those reported in the above Tables are not considered important in terms of their potential impact on the heat transfer between primary and secondary, nor on the results of the benchmark analyses.

QUESTION # 5

QUESTION: **Explain how FPL has used the benchmark analysis results (agreement or disagreement with data) in RETRAN modeling of the licensing type applications.**

FPL RESPONSE:

As stated in Reference (2) (page 4 of the Combined Answer to NRC Safety Analysis Questions Nos. 1 and 2 and NRC Limiting Transient Questions Nos. 1 and 2), sensitivity studies performed on the benchmark analyses confirmed that the modeling approaches selected for the methodology in Reference (1) are acceptable. In addition, the RETRAN predicted system heatup and ensuing peak pressures for the benchmark events were used to verify that the selected modeling approaches are conservative. The RETRAN model was not optimized beyond each event's heatup period since the proposed RETRAN methodology is only intended for heatup type events.

QUESTION # 6

QUESTION: In Benchmark Analysis # 2, explain why RETRAN predictions of Pressurizer pressure and RCS temperature are not both consistent with plant data.

FPL RESPONSE:

The inconsistency between the RETRAN predictions and plant data in the second half of the analysis is an issue already addressed in Reference (2) (Section 3.3) and in Reference (2) (Question #2). Several sensitivity studies and interpretations for the discrepancy are presented in both references. The first portion of the transient which includes the heatup and the RCS and secondary peak pressures and temperatures were reasonably well predicted with RETRAN. The discrepancy is in the second part of the transient or depressurization phase.

The work documented in References (1) and (2) investigated the effects of unpredicted Main Steam Safety Valve actuation regarding the above inconsistency. However, it is possible that the RETRAN pressurizer model used in the analysis may have contributed to accentuate the inconsistency with plant data. This model is the same as that used in the licensing analyses of heatup events and is designed to maximize the insurge peak pressure. To this effect, wall heat transfer, which can be important during depressurization was intentionally ignored (see Reference (1) Section 1.2.3.1). In addition, the combination of no inter-region heat transfer and full mixing assumptions, may also play a role in the depressurization rate in the RETRAN model. The effect of these assumptions during pressurizer outsurges is of no relevance for the scope of the proposed FPL Heatup Methodology. The benchmark analyses included in Reference (1) were used to verify that the pressurizer model conservatively overpredicts peak pressure during insurges. The model has not been modified to match plant data during depressurization.

QUESTION # 7

QUESTION: On the RETRAN heatup licensing analyses, provide the following additional information. Discussion should be carefully thought out and thorough. Provide all necessary information (references) to support FPL's conclusions.

- When choosing assumptions/inputs that are different than those in the corresponding FSAR analysis, provide discussion of impact on results.

- Provide FSAR and RETRAN plots for the Turkey Point Loss of AC Analysis and justify the differences.

FPL RESPONSE:

As discussed in Section 4.1 of Reference (1), for the events in the Decrease in Heat Removal from the Secondary System category, the key acceptance criteria is maintaining peak pressures, both primary and secondary, below 110% of design. Pressurizer level must also be examined since there is a potential for going water solid in the pressurizer during these events. In addition, for the Loss of Normal Feedwater event an additional safety concern is maintaining an adequate water level in the SG's to remove decay heat. These criteria formed the basis for choosing the limiting transients within this category and our determination of the limiting input for the FPL safety methodology. DNBR behavior is bounded by the results of the Loss of Flow event and is not specifically calculated for these types of transients.

For St. Lucie Unit 1, the limiting event for this category is the Loss of Condenser Vacuum presented in Section 4.2.1.3 of Reference (1). The analysis objective for this transient is to determine if the acceptance criteria as stated in the Standard Review Plan is met utilizing conservative inputs. Peak primary and secondary pressure are examined to ensure that they remain below the 110% design limit value.

A qualitative discussion of the key input parameters for this transient and the basis for our choice is described in Reference (1). The initial conditions were chosen such that the time to reactor trip on high pressure is maximized so that a high rate of change of pressure is achieved. A quantitative description of the key parameter values utilized is discussed below.

1) Maximum possible power, 102% of rated power is assumed in order to ensure that the maximum power is released to the primary system during the course of the transient. The greater the power input into the primary, the larger the pressure increase as the secondary side heat removal capacity is decreased. St. Lucie Unit 1 rated power is 2700 MWth; a

value of 2754 MWth was used in the analysis.

2) The minimum initial primary pressure is assumed in order to increase the time from initiation of the event to the high pressure trip setpoint. Delaying the reactor trip allows the primary pressure rate of increase to be maximized as well as more total energy to be released into the primary system. This results in a conservative peak primary pressure. St. Lucie Unit 1 nominal pressure is 2250 psia. Subtracting 22 psia for uncertainty and 25 psia for operating band allowance results in the value of 2203 psia used in the analysis.

3) The minimum inlet temperature is assumed in order to decrease the secondary side pressure to a minimum. A low value for secondary side pressure produces the longest delay in the opening of the secondary safety valves and consequently a reduced energy removal from the secondary side. The low secondary side pressure, therefore, results in a maximum primary pressure increase. In addition, it results in a large rate of increase in pressure in the secondary side which results in the maximum peak secondary pressure. The nominal inlet temperature is 549 °F. Subtracting a 2 degree uncertainty results in the value of 547 °F used in the analysis. In addition an analysis assumption for the maximum value of Steam Generator Tube Plugging (15%) is used which also minimizes secondary side initial pressure.

4) The minimum Technical Specification value for primary flow, 370,000 gpm, is used to minimize primary to secondary heat transfer.

5) A Moderator Temperature Coefficient consistent with the Technical Specification value is assumed. St. Lucie Unit 1 has an MTC limit of less than +2.0 pcm/°F whenever Thermal Power is greater than 70% power. A value of +2.0 pcm/°F, therefore, was used in the analysis. A positive MTC value will result in reactor power increasing as temperature increases. This assumption allows the maximum power to be generated in the primary side during the transient which will result in maximum values for both primary and secondary pressures.

6) The least negative Doppler coefficient is chosen for this transient. For the purposes of the evaluation in Reference (1), the vendor calculated value with their recommended uncertainty is utilized. The least negative Doppler coefficient provides the least feedback as the power is increasing and results in more power being generated throughout the transient with a corresponding larger primary and secondary peak pressure.

In addition, conservative values for control rod worth and axial shape are chosen to minimize the negative reactivity associated with the reactor scram. For the evaluation in Reference (1), vendor calculated values with appropriate uncertainties were used.

For St. Lucie Unit 2, the limiting event for this category is the Loss of Condenser Vacuum presented in Section 4.2.2.3 of Reference (1). The basis for the analysis inputs is presented qualitatively in Reference (1), the discussion that follows will provide the specific values along with justification for each value. The impact of each parameter relative to the objective of the transient is the same as discussed above for St. Lucie Unit 1 and will not be repeated.

1) The maximum power is 102% of the rated thermal power. St. Lucie Unit 2 has a rated thermal power of 2700 MWth. Therefore, a value of 2754 MWth is assumed in the analysis.

2) The minimum RCS initial pressure is calculated by subtracting the nominal pressure (2250 psia) by the uncertainty and the operating band allowance. An uncertainty of 58 psia and a operating band allowance of 25 psia results in the minimum pressure of 2167 psia.

3) The minimum inlet temperature for St. Lucie Unit 2 represents the worst case inlet minus uncertainties. The Technical Specification minimum value of 535 °F minus 3 °F uncertainty yields a value of 532 °F as the analysis assumption. In addition, a Steam Generator tube plugging value of 17.8% was assumed in this analysis.

4) The minimum Technical Specification flow of 363,000 gpm was assumed for this analysis.

5) The maximum Technical Specification value for MTC at greater than 70% power is +3.0 pcm/°F which was assumed for this analysis.

6) The least negative Doppler coefficient, minimum control rod worth and a bottom peaked axial shape were chosen to maximize the peak pressure of this transient.

For Turkey Point Units 3 & 4, the limiting event for this category is the Loss of Condenser Vacuum presented in Reference (1) Section 4.2.3.3. The basis for the analysis inputs is presented qualitatively in Reference (1). The discussion that follows will provide the specific values along with justification for each value. The impact of each parameter relative to the objective of the transient is the same as discussed above for the St. Lucie Unit 1 analysis and will not be repeated.

1) The power level input into the analysis represents 102% of the rated power of the Turkey Points Units of 2200 MWth.

2) The initial pressure value (2200 psia) conservatively bounds the nominal operating pressure of 2250 psia less an

uncertainty of 40 psia.

3) The minimum inlet temperature is calculated by utilizing the nominal inlet of 546.2 °F less a 4 degree uncertainty. In addition, a Steam Generator Tube Plugging level of 5%, well above the actual tube plugging at the plant, is assumed in the analysis.

4) The Technical Specification minimum value of 268,500 gpm is used as the analysis input for flow rate.

5) A Moderator Temperature Coefficient of +2.0 pcm/°F was assumed for the analysis. Turkey Point Technical Specifications allows a rampdown of the MTC as a function of power, e.g., from 70 percent power to 100 percent power, the MTC goes linearly from +5 to 0 pcm/°F. The value of +2 pcm/°F is conservative for full power calculations.

6) The Doppler Coefficient utilized is consistent with the FSAR analysis value.

The Loss of Non-emergency AC Power to the Station Auxiliaries analysis,(Reference (1) Section 4.2.3.6), was presented for Turkey Point Units 3 & 4 in order to demonstrate that sufficient heat removal capacity is available to ensure that the pressurizer does not become water solid. This threat comes from the fact that the secondary side heat sink may be lost for a period of time prior to the delivery of auxiliary feedwater or that the quantity of auxiliary feedwater may not be sufficient to remove the primary side decay heat. This risk of a water solid pressurizer ends when the heat removed by the auxiliary feedwater flow matches the rate of decay heat into the system.

Several highly conservative assumptions were incorporated into this analysis to maximize the likelihood of a water solid pressurizer. They are discussed in depth in Reference (1) Section 4.2.3.6. For completeness these assumptions are restated below.

- No reactor trip on Loss of AC (LOAC) power signal. This signal is only assumed to trip the main feedwater pumps while continuing to permit 100% reactor power. Keeping the reactor at full power while there is no effective heat sink maximizes the RCS energy and the rate of steam generator inventory depletion. Early steam generator dryout and subsequent loss of heat sink increases the likelihood of a water solid pressurizer.

- The trip of the reactor coolant pumps on LOAC or on low RCS flow signals is not credited. Keeping the pumps running until the occurrence of reactor trip signal on low steam generator level also maximizes the RCS energy and thus the likelihood of a water solid pressurizer. This assumption

together with that of delaying the reactor trip on LOAC signal means that the FPL LOAC analysis neglects the first two reactor trip signals that would be expected to occur during this event.

- A conservatively high value of decay heat. A 1.2 multiplier on the ANS 1971 decay heat function is used in the FPL LOAC analysis. This, like the above assumptions, also has the effect of maximizing the RCS energy and thus the likelihood of a water solid pressurizer.

- A conservatively low value for the steam generator water level trip. The value used in the RETRAN analysis is conservative with respect to the Turkey Point Technical Specifications. This value will delay the time of the reactor trip and the time of auxiliary feedwater delivery which will also maximize the RCS energy and the likelihood of a water solid pressurizer.

In addition to the above conservative methodology, input parameters were also specially selected to either maximize system energy or minimize the energy removed by the secondary side in order to increase the likelihood of a water solid pressurizer. The key input parameters chosen were:

1) Maximum initial power level, 102% of rated power.

2) Maximum initial primary pressure and temperature were assumed to maximize the initial water density within the primary system. The maximum pressure is the nominal (2250 psia) plus 40 psia uncertainty. The maximum inlet temperature is 546.2 ^{o}F (nominal) plus 4 degree uncertainty.

3) The minimum RCS flow and maximum Steam Generator Tube Plugging are assumed to minimize primary to secondary heat transfer. The minimum Technical Specification flow of 268,500 gpm and 5% tube plugging were therefore utilized.

4) A conservative positive MTC and least negative Doppler Coefficient were utilized. The MTC (+2.0 pcm/^{o}F) is more positive than that allowed by Technical Specifications.

Figures 1 trough 4 show that there is reasonable agreement between the FSAR and RETRAN results. Differences between the two predictions are attributable to differences between LOFTRAN and RETRAN and in large part are due to differences in the way the heat transfer between the primary and secondary systems is modeled in each analysis. The FSAR calculation uses a Single Node Steam Generator (SNSG) model. To overcome the non-conservatism of the overall instantaneous mixing of the auxiliary feedwater fluid in this type of representation, the heat transfer coefficient is artificially altered in the conservative direction. In the FPL analysis, with the use of a Multinode Steam Generator (MNSG) model, the addition of the auxiliary feedwater fluid is more realistically represented and there is no need for alteration of the code calculated heat transfer coefficients. The different responses predicted by the SNSG and the MNSG models for this transient are described in the (Reference (2) (General Approach Question # 1).

Differences in the way primary to secondary heat transfer is modeled in each analysis probably explain the different responses to the reactor coolant pumps and turbine trips which happen at about the same time. The resulting cold leg temperature and pressurizer pressure increases are substantially more pronounced in RETRAN than in the FSAR (Figures 1 and 4). Later on, in the RETRAN analysis, the more realistic heat transfer between primary and secondary results in the RCS heatup being turned around shortly after the operator increases the auxiliary feedwater flow from 110 to 230 gpm at 652 seconds.

The results of the LOAC power RETRAN analysis show a peak pressurizer liquid volume of 1020 cu. ft. at 12 minutes after event initiation. Since the actual pressurizer volume at Turkey Point is approximately 1328 cu. ft., there is substantial margin to the water solid condition even with the use of highly conservative assumptions. As discussed in Reference (1), Turkey Point's RETRAN model has been evaluated via benchmarks with plant operational data. Lessons learned from this evaluation have been factored into the development of the RETRAN licensing model used in the LOAC power analysis. Our judgement is that these benchmarks, combined with the use of the conservative assumptions reiterated in this response, provide confidence that FPL can appropriately model the LOAC power transient for Turkey Point and that the results of this analysis will be consistent with acceptance criteria.

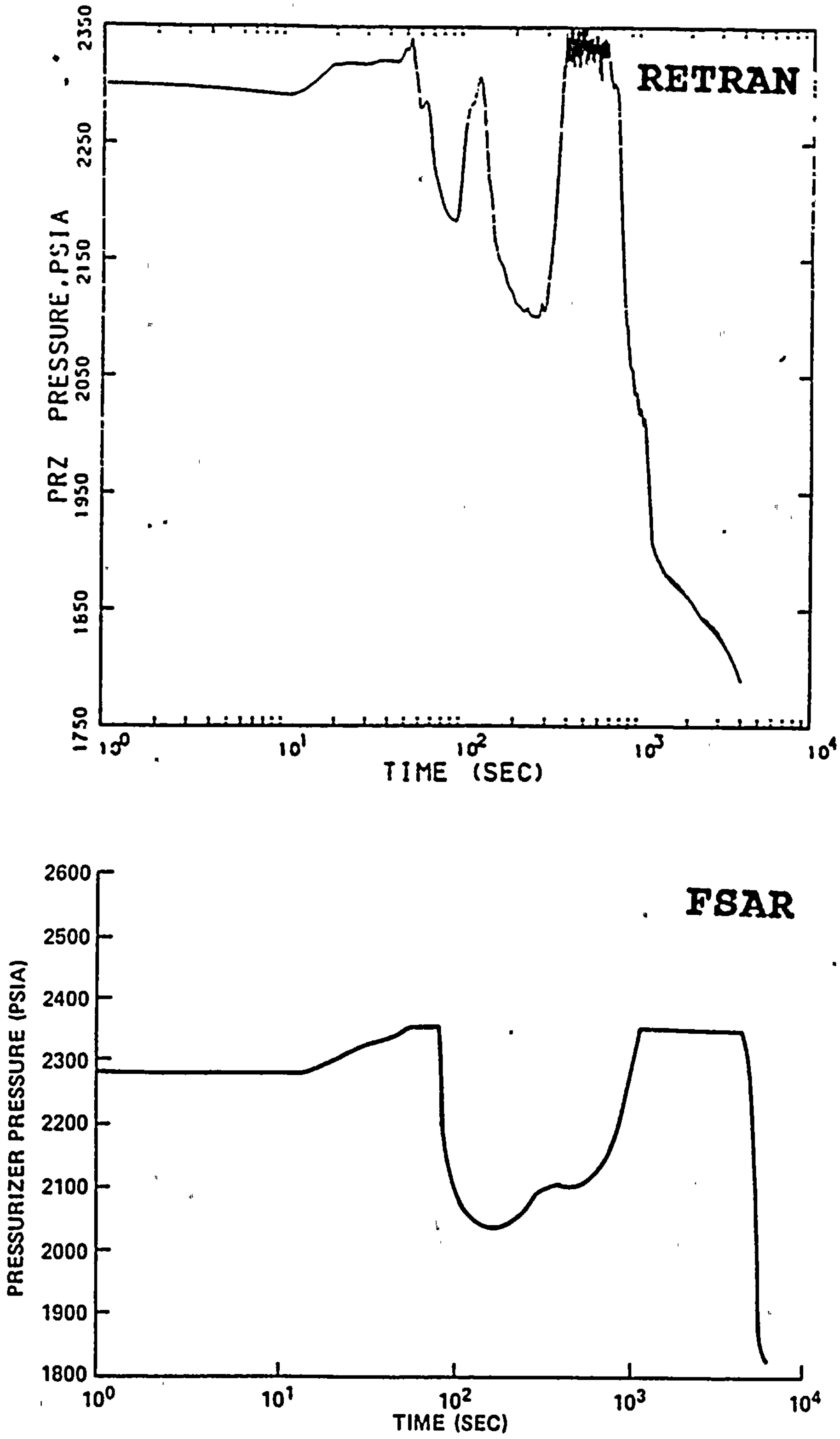


Figure 1. PRESSURIZER PRESSURE

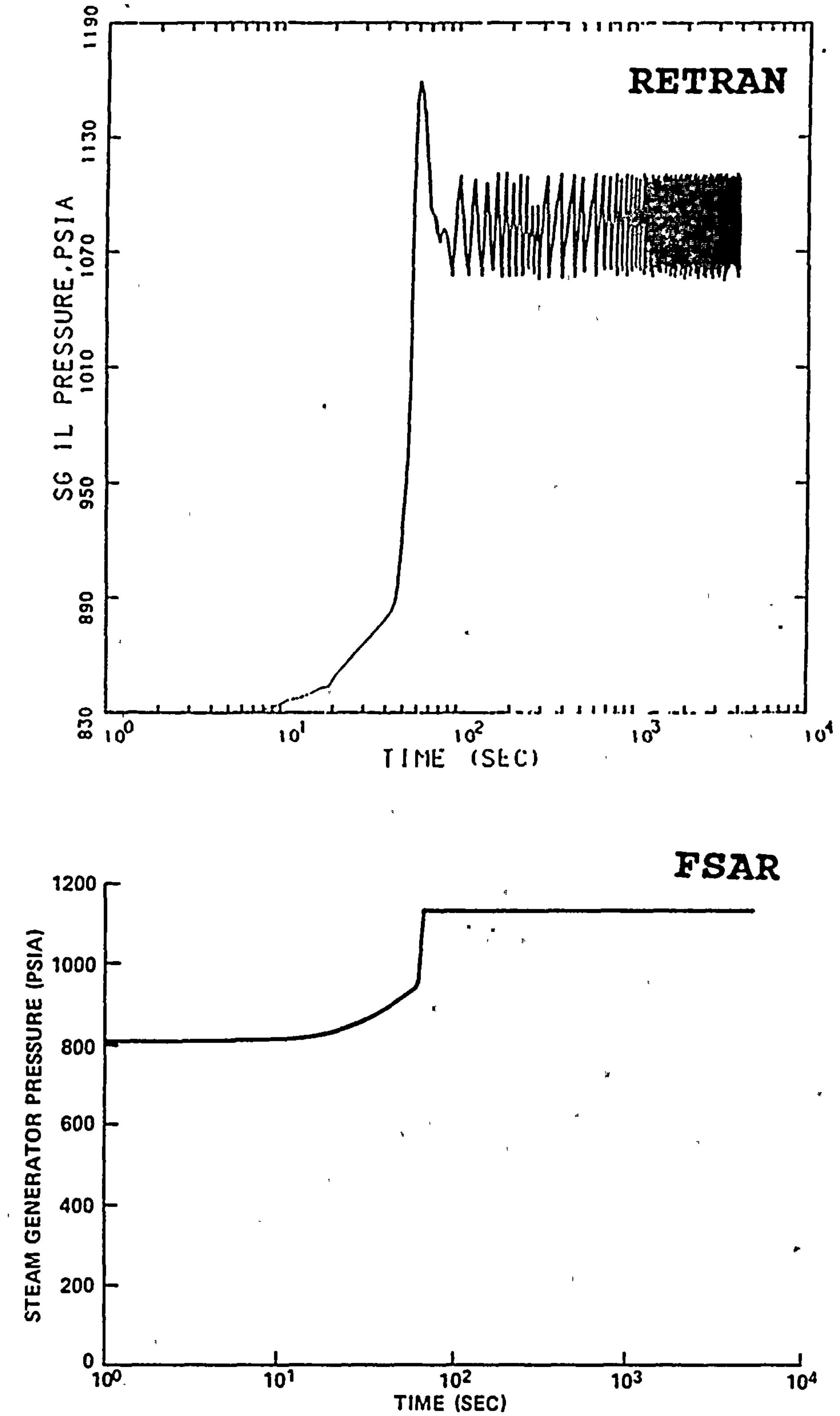


Figure 2. STEAM GENERATOR PRESSURE

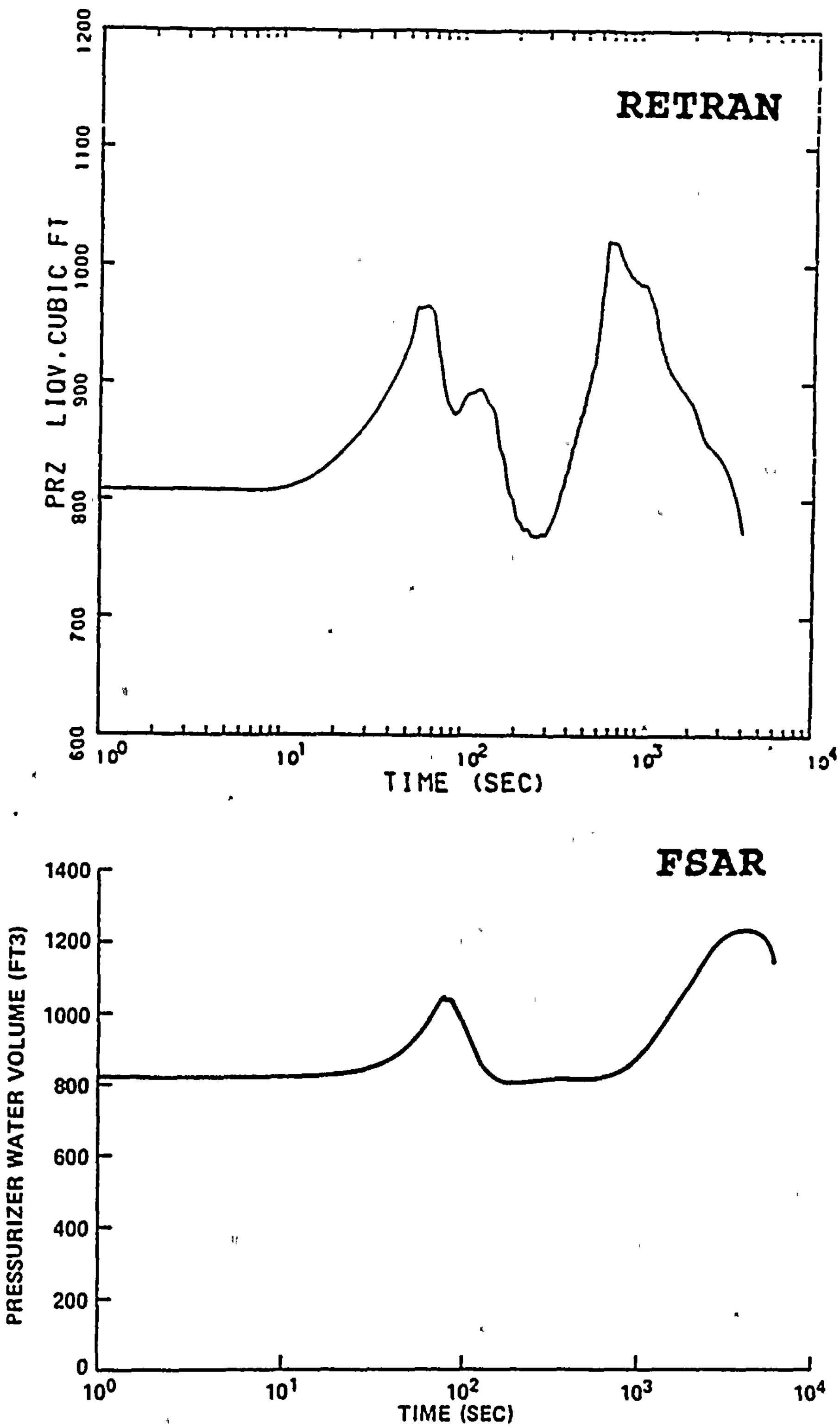
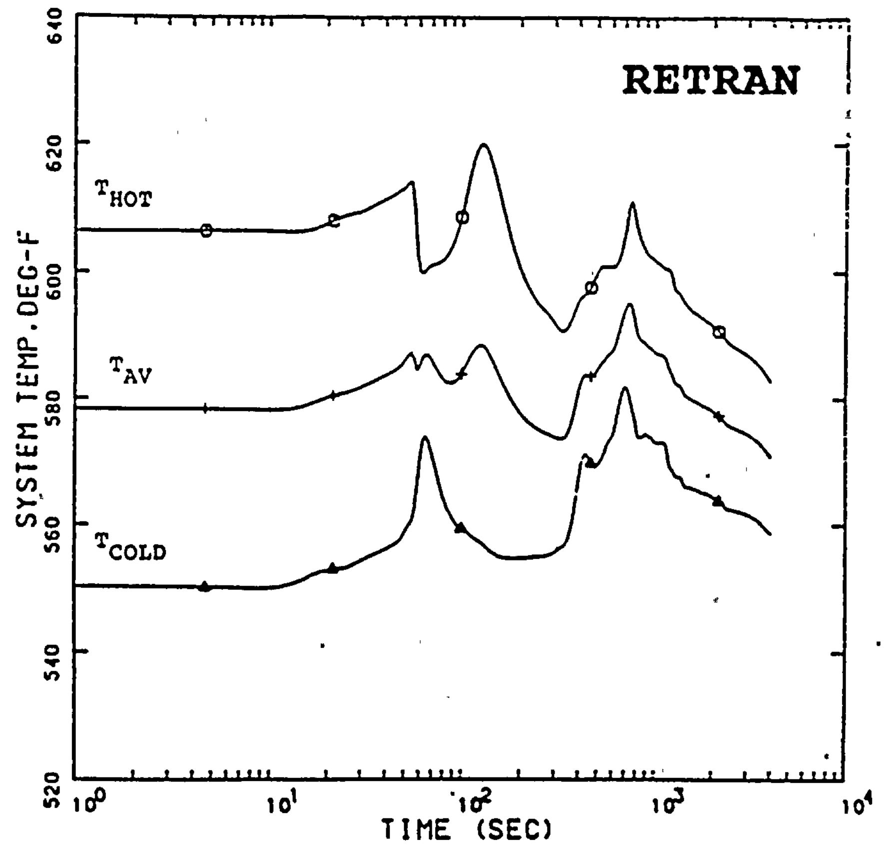


Figure 3. PRESSURIZER WATER VOLUME



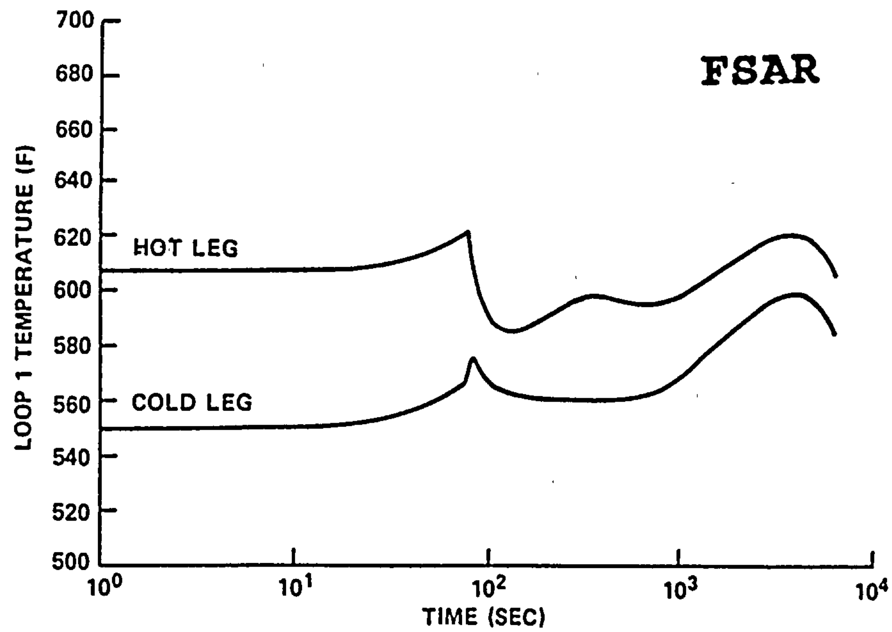


Figure 4. RCS TEMPERATURES

QUESTION # 8

QUESTION: **State the analysis objectives (peak RCS pressure, peak SG pressure, worst DNB, potential for PZR water solid, etc.) for each of the licensing type analyses and justify initial conditions used to address each objective for all transients in this category.**

FPL RESPONSE:

Each of the licensing type analyses is discussed in detail, in terms of their respective analyses objectives, in Section 4.2 of Reference (1).

Justification of the initial conditions and assumptions used in the licensing type analyses is provided in Reference (2) (Question #7).

QUESTION # 9

QUESTION: Discuss (1) decay heat modeling, (2) reactivity coefficients used.

FPL RESPONSE:

The analyses and methodology presented in Reference (2) have been analyzed with RETRAN02 MOD04 and therefore use the 1973 ANS Standard Decay Heat Model. The Turkey Point Loss of Non-Emergency AC Power RETRAN analysis in Reference (1), being the only event where decay heat is of significance, has been analyzed with a 1.20 multiplier on the code predicted decay heat. This is to account for the large uncertainties in the 1973 ANS Standard. No correction to the decay heat model has been included in any of the other licensing transients in Reference (1) because they are all analyzed for a very short duration.

All the licensing analyses in Reference (1) use constant reactivity coefficients. These coefficients are documented on Tables 4.2.1.3-1, 4.2.2.3-1, 4.2.3.3-1 and 4.2.3.6-1 in Reference (1).

The St. Lucie 1 event benchmarked in Reference (1) has also been analyzed with constant reactivity coefficients because no cycle best estimate coefficients were available at the time of the analyses. The coefficients used correspond to BOC conditions provided by the vendor for Cycle 9 reload. The event which took place at the beginning of Cycle 9 resulted in a rather mild RCS heatup. Therefore small differences between best estimate and licensing values for the kinetics parameters are not expected to significantly affect the results of the benchmark analysis.

The code option that allows for a functional representation of the reactivity coefficients (reactivity vs. coolant density and fuel temperature) was used for the Turkey Point benchmark analysis in Reference (1). The respective MTC and Doppler Coefficient tables and their associated weighting factors correspond to Cycle 10 (MOC). The event took place during Cycle 11 (MOC). The reactivity parameters between the two cycles were very similar and therefore it was concluded that Cycle 10 kinetics parameters were appropriate for the analysis.

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 and 4 (TAC Nos. 75082, 75083, 75084, 75085), dated May 2, 1991.

(3) W.W.R. Inch, "Thermal-Hydraulic Analysis of the Combustion Engineering Series 67 Steam Generator", EPRI NP-1678, Project S130-1, Final Report January 1981.