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L-93-242

U.S. Nuclear Regulatory Commission
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Re: Response to Request for Additional Information Related to Topical Report NTH-TR-01, RETRAN Model Qualification - St. Lucie Plant Unit Nos. 1 and 2 (Docket Nos. 50-335 and 50-389) and Turkey Point Plant Units Nos. 3 and 4 (Docket Nos. 50-250 and 50-251 (TAC Nos. 75082, 75083, 75084 and 75085)

On June 25, 1993, 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." Per letter L-93-194, dated August 9, 1993, a description was provided detailing how FPL was going to respond to each of the questions resulting from the call, as well as a schedule. The purpose of this letter is to provide FPL's response to the request for additional information (attached).

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

Very truly yours,

for WHB

W. H. Bohlke
Vice President
Nuclear Engineering and Licensing

WHB/msd

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant
Senior Resident Inspector, USNRC, St. Lucie Plant

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QUESTION # 1

In the SG model, the single node is not justified. Is it better or worse and why?

Numerical convergence of multinode is not discussed, for example to show that nothing is gained by going to multinode.

The FPL methodology (References 1, 2, 3 and 4) to analyze licensing events involving decrease in heat removal by the secondary system is based on two different modeling approaches for the steam generator secondary side. For events not requiring steam generator water level prediction, a Single Node Steam Generator (SNSG) model will be used while a Multinode Steam Generator (MNSG) model will be used when water level prediction is required.

The Loss of Load or Loss of Condenser Vacuum type transient for both the Turkey Point and St. Lucie units is an example of the events not requiring level prediction which will be analyzed with the SNSG model. The alternative to the SNSG model would have been the MNSG model. However, sensitivity analyses, summarized in the Answer to Question # 3 of this submittal, show that the two models predict nearly identical responses and that the SNSG response is slightly more conservative. Therefore, because of its conservatism, the SNSG is the model that will be used in the FPL methodology to analyze the Loss of Load type events.

Specifically, the Loss of Load transient is characterized by the sudden closure of the turbine stop valves and the termination of the feedwater flow at the transient initiation. System overpressurization is the concern for this type of event. Overpressurization occurs as a result of the closure of the turbine stop valves and subsequent loss of an efficient secondary heat sink for the primary heat.

A SNSG representation, as the one used in the analyses of the Loss of Load type transients, combines the entire shell side of the steam generator into one single large volume. In a MNSG representation, on the contrary, the shell side is divided into downcomer, tube bundle, separator and steam dome regions. The steam dome region or vapor volume in the MNSG model is smaller than the shell side volume in the SNSG model. Because of its more detailed nodalization, the MNSG running times are longer by about a factor of two. Initializing the model with the appropriate conditions, recirculating flows and liquid inventory without numerical convergence errors is difficult and requires an iterative process. Additionally, in the SNSG model, the entire shell side volume is at saturation conditions while in the MNSG only the inventory in the tube bundle, separator and steam dome regions are at saturation conditions. The inventory in the downcomer is at subcooled conditions.

In a Loss of Load event, after the turbine valves close, the pressurization rate of the vapor region is higher with the MNSG than with the SNSG because of the smaller vapor volume in the MNSG model. Consequently, the MNSG predicts earlier Main Steam Safety Valves (MSSV) opening than the SNSG model. This provides earlier relief for the primary system energy and tends to reduce the severity of the overpressurization event with the MNSG model. In the MNSG model, once the turbine valves close and the feedwater flow stops, flow recirculation within the steam generator continues with subcooled fluid from the downcomer region flowing along the tubes in the tube bundle. This provides some additional relief for the primary system energy that the SNSG model with its lack of recirculation capability cannot provide. The MSSV opening delay and the lack of a recirculation model cause the SNSG to conservatively predict system behavior. As a result, the SNSG is a good model for licensing applications.

For the Loss of Load transients of interest here, where peak primary pressures occur within the first 11 seconds of the transient, the impact of the two effects described above is small. Its relative importance varies with plant design and transient conditions. This is illustrated in the Answer to Question # 3 in this submittal.

It should be noted that while the MNSG model provides a more realistic secondary side plant response, the choice of the SNSG model is appropriate for the Loss of Load type transient. FPL retains the MNSG representation for best estimate analyses and for licensing analyses where the prediction of the steam generator water level is important. An application of this model is in the licensing analysis of the Turkey Point Loss of AC Power event discussed in References 1 and 4 and in the Answer to Question # 2 of this submittal.

Appendix A, provides details of an FPL review of pertinent industry references on the subject of SNSG modeling. Based on NRC-approved topical reports, published papers, accepted vendor licensing analyses and FPL studies presented here and in References 1 through 4, it can be concluded that the SNSG model is the model of choice for Loss of Load licensing type calculations. This is because of its conservatism and simplicity and because the licensing analysis results for the Loss of Load type transients are not dependent on an accurate prediction of the steam generator water level. The FPL licensing analyses of this type of transient will be based on the SNSG representation.

QUESTION # 2

How do you compute SG liquid mixture level? What you do, is it appropriate and conservative? How do you determine what is the right mass in determining the setpoint for the low-low SG level setpoint. Benchmarking of same.

The steam generators at the Turkey Point Units 3 and 4 and the St. Lucie Units 1 and 2 are of the U-tube type with integral moisture separating equipment and no preheater. No significant differences exist between the steam generators at each site (References 5, 6 and 7). Table 1 summarizes their main characteristics.

The water level in each steam generator is maintained by a three-element control system which continuously compares measured feedwater flow with steam flow and measured steam generator water level with a level setpoint. The system compares all the factors involved and generates an electrical signal that is converted into an air signal used to control the position of the feedwater regulating valve, and thereby, the steam generator water level.

The water level controllers described above are not included in the RETRAN models used in the FPL Methodology of Reference 1 because steam generator level control is not credited in licensing applications. However, certain transients require tracking of steam generator water level in order to accurately predict the reactor protection trip signals which are associated with low steam generator water level. An example of such transients is the Turkey Point Loss of AC Power analyzed in the FPL Methodology presented in References 1 and 4. Water level prediction requires a detailed or multinode steam generator representation in RETRAN. The method to compute steam generator water level in the Turkey Point and the St. Lucie RETRAN multinode steam generator models is the same. It is based on a relationship between free available volume in the region outside the tube bundle wrapper and the height above the tube sheet. This relationship can either be extracted from the steam generator design manuals or can be directly calculated from detailed steam generator drawings. Geometry changes between the upper shell, transition cone and lower shell need to be taken into consideration in the computation of the free available volume in the region. Measured water level is inferred from the relative location of the respective low and high water level taps. This volume versus level function is used in the RETRAN multinode steam generator models in an algorithm that predicts steam generator water level in terms of the combined liquid volume in the downcomer volumes.

The above approach is used to predict the time to reach the low steam generator water level setpoint in the Turkey Point Loss of AC Power analysis reported in References 1 and 4. In that transient,

the time of the low water level signal is a key parameter because the reactor trip and the auxiliary feedwater system signals are generated based upon this signal. The time of the low level trip predicted by RETRAN is within 1 second of that predicted by the vendor (Reference 4). The liquid inventory remaining in each steam generator at the time of the low level trip in the RETRAN analysis is 37,459 lbm. Based on conversations with the vendor, this inventory is lower than that used in their corresponding FSAR analysis. Therefore, the Turkey Point RETRAN multinode steam generator model provides a water level prediction which is in good agreement and more conservative than that used by the vendor.

The performance of the level predictor algorithm in the Turkey Point RETRAN multinode steam generator model, for the Loss of AC Power transient, is consistent with that of the St. Lucie multinode steam generator model in the plant event benchmark presented in Reference 1. For that event, the predicted steam generator water level response is in good agreement with the measured level with RETRAN also predicting an earlier low level trip signal. Overall, it can be concluded that the RETRAN multinode steam generator models for Turkey Point and St. Lucie, since they are both based on the same modeling philosophy, provide a level prediction capability which is in good agreement, though conservative, when compared to both vendor analyses and plant data.

QUESTION # 3

Why is the Single Node Steam Generator model adequate for W and CE plants in the Loss of Condenser type analyses. Plant differences?

The Loss of Condenser Vacuum analyses, with a Single Node Steam Generator (SNSG) model, for St. Lucie Unit 1 and Turkey Point Units 3 and 4 included in Reference 1 have been reanalyzed with a Multinode Steam Generator (MNSG) model to assess the relative impact of steam generator modeling and differences in plant designs. Previously, the impact of steam generator modeling had only been evaluated for Turkey Point (Reference 4). Based on the comparison analyses for both plants, it can be concluded that the system overpressurization predicted by both steam generator models are very similar with the SNSG yielding slightly more conservative results. This conclusion will also apply to the LOCV analysis for St. Lucie Unit 2, included in Reference 1, which has not been reanalyzed here because the steam generators for both St. Lucie units are practically identical. The Answer to Question # 2 in this submittal provides details on the similarity of the steam generators in both units and of their respective RETRAN models.

Figures 1 through 3 show the comparisons of primary and secondary responses predicted with the SNSG and the MNSG for the St. Lucie Unit 1 Loss of Condenser Vacuum (LOCV) transient. Figures 4 through 6 show the corresponding comparison for the Turkey Point units. Both LOCV transients, described in detail in Reference 1, are based on conservative assumptions, such as instantaneous isolation of the feedwater flow at the beginning of the event.

The St. Lucie LOCV scenario is dominated by an early opening of the Main Steam Safety Valves (MSSVs) which precedes the reactor trip signal and pressurizer safety valve opening on high pressure. The MNSG model, with a 1-second earlier MSSV opening than the SNSG (which opens MSSVs at 6.6 seconds), results in less energy accumulated in the system and therefore less system overpressurization. The impact of this, however, is not significant. The differences in peak pressures predicted by the two models are about 7 psi for the primary system and 3 psi for the secondary system.

At Turkey Point, the MSSVs' opening setpoint is higher than that at St. Lucie. This results in the Turkey Point LOCV event not being dominated by early MSSV opening as it is in the St. Lucie event. In this scenario, the Pressurizer Safety Valves open first (at 8 seconds), making the relief of primary energy less dependent on the secondary heat sink than in the St. Lucie scenario. The primary system response predicted by the SNSG and MNSG models for this event is essentially identical with less than 1 psi difference in peak pressures. On the secondary side, the difference in peak pressures is about 5 psi.

A previous sensitivity analysis with a Turkey Point Loss of Load event (Reference 4) reported the MNSG slightly overpredicting the SNSG system pressure which is the opposite of the behavior described above. The reason for this difference is that the feedwater flow in that event was kept constant throughout the transient. This resulted in a better heat sink for the primary energy in the SNSG than in the MNSG which produced lower pressures in the SNSG model.

Based on the comparisons between the SNSG and MNSG responses illustrated in Figures 1 through 6, it can be concluded that the SNSG model is a valid model for licensing analyses of St. Lucie and Turkey Point Loss of Load type transients. For these events, where the relevant transient time is too short for a significant loss of steam generator inventory to occur and where the level in the steam generator is not a parameter of importance, a detailed steam generator representation is not necessary. The SNSG model provides a response that is very similar to that predicted by the MNSG model but is more conservative and therefore more appropriate for licensing applications. The SNSG is the model which will be used in the FPL methodology for both Turkey Point and St. Lucie licensing analyses of the Loss of Load type events.

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 Unit Nos. 1 & 2 and Turkey Point Plant Unit Nos. 3 & 4 (TAC Nos. 75082, 75083, 75084, 75085), dated May 2, 1991. Answers to General Approach Question # 1.

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

4. FPL letter L-93-39, "Response to Request for Additional Information Related to Topical Report NTH-TR-01, RETRAN Model Qualification St. Lucie Unit Nos. 1 & 2 and Turkey Point Plant Unit Nos. 3 & 4 (TAC Nos. 75082, 75083, 75084, 75085), dated February 16, 1993.

5. Vertical Steam Generator Instructions for Florida Power and Light Company Turkey Point Units No. 3 and No. 4 , Volume 1 , Technical Manual 1440-C302, Document Review No. SG-79-02-056, Westinghouse General Order No. MI-25310-AR6/AR5.

6. Steam Generators, St. Lucie Plant Unit 1, Instruction Manual, CE Book No. 74267, December 1972. Florida Power & Light St Lucie Unit 1 Technical Manual 8770-5008.

7. Steam Generators, St. Lucie Plant Unit 2, Instruction Manual, CE Book No. 71272, October 1977. Florida Power & Light St Lucie Unit 2 Technical Manual 2998-5253.

Table 1

STEAM GENERATOR CHARACTERISTICS

PARAMETER	TURKEY POINT UNITS 3 & 4	ST. LUCIE UNIT 1	ST. LUCIE UNIT 2
Number of Steam Generators	3	2	2
Evaporator Diameter (ft. O.D.)	10.58	13.76	13.76
Steam Drum Diameter (ft. O.D.)	13.67	19.98	19.98
Overall Length (ft)	63.14	62.42	62.42
Number of Tubes	3214	8519	8411
Tube O.D. (in)	0.875	0.750	0.750
Tube Wall Thickness (in)	0.050	0.048	0.048
Heat Transfer Area (ft^2)	43,467	91,302	90,144
Liquid Mass Inventory at HFP (lbm)	85,837	131,612	131,602

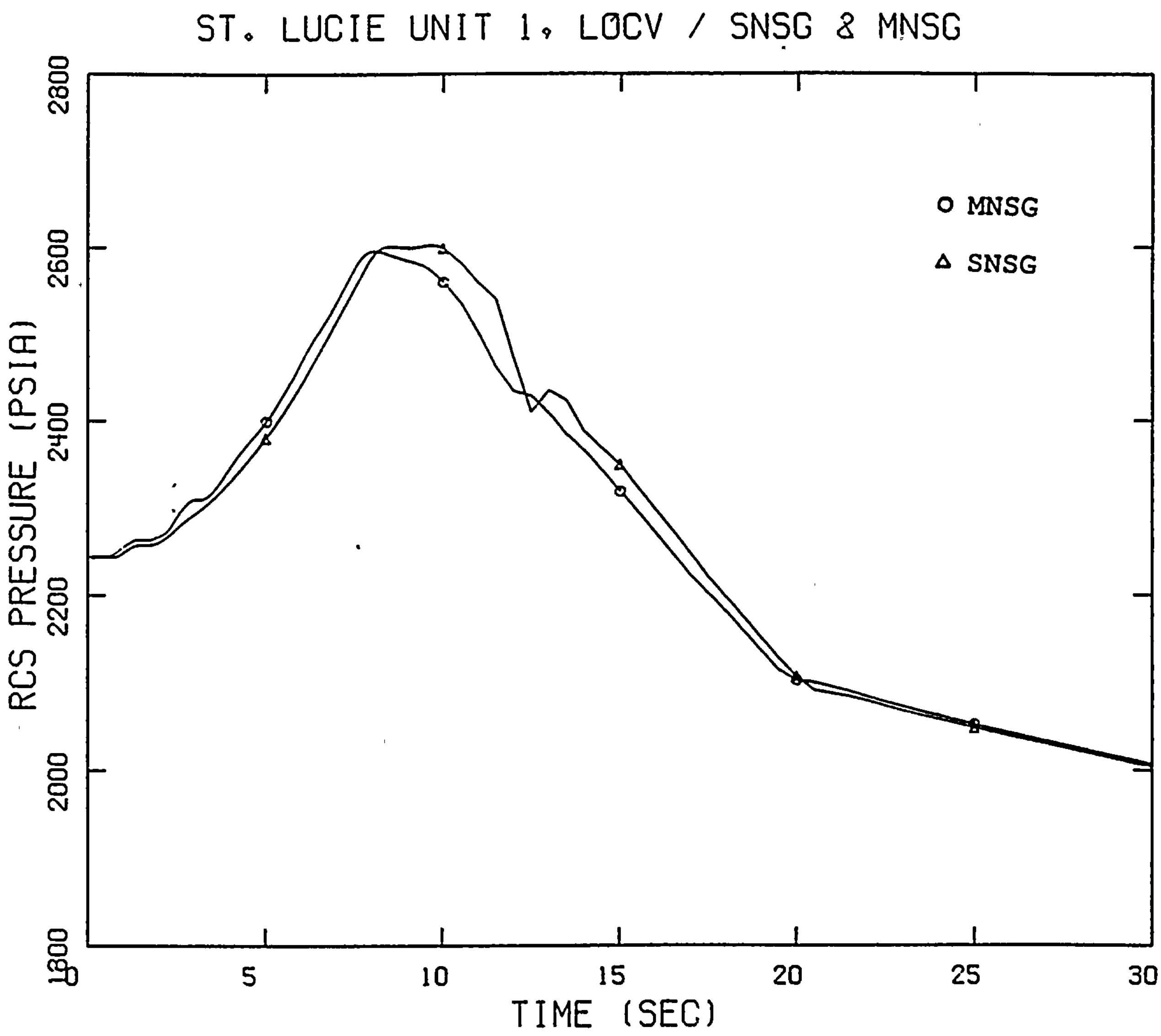

FIGURE 1. ST. LUCIE 1, RCS PRESSURE

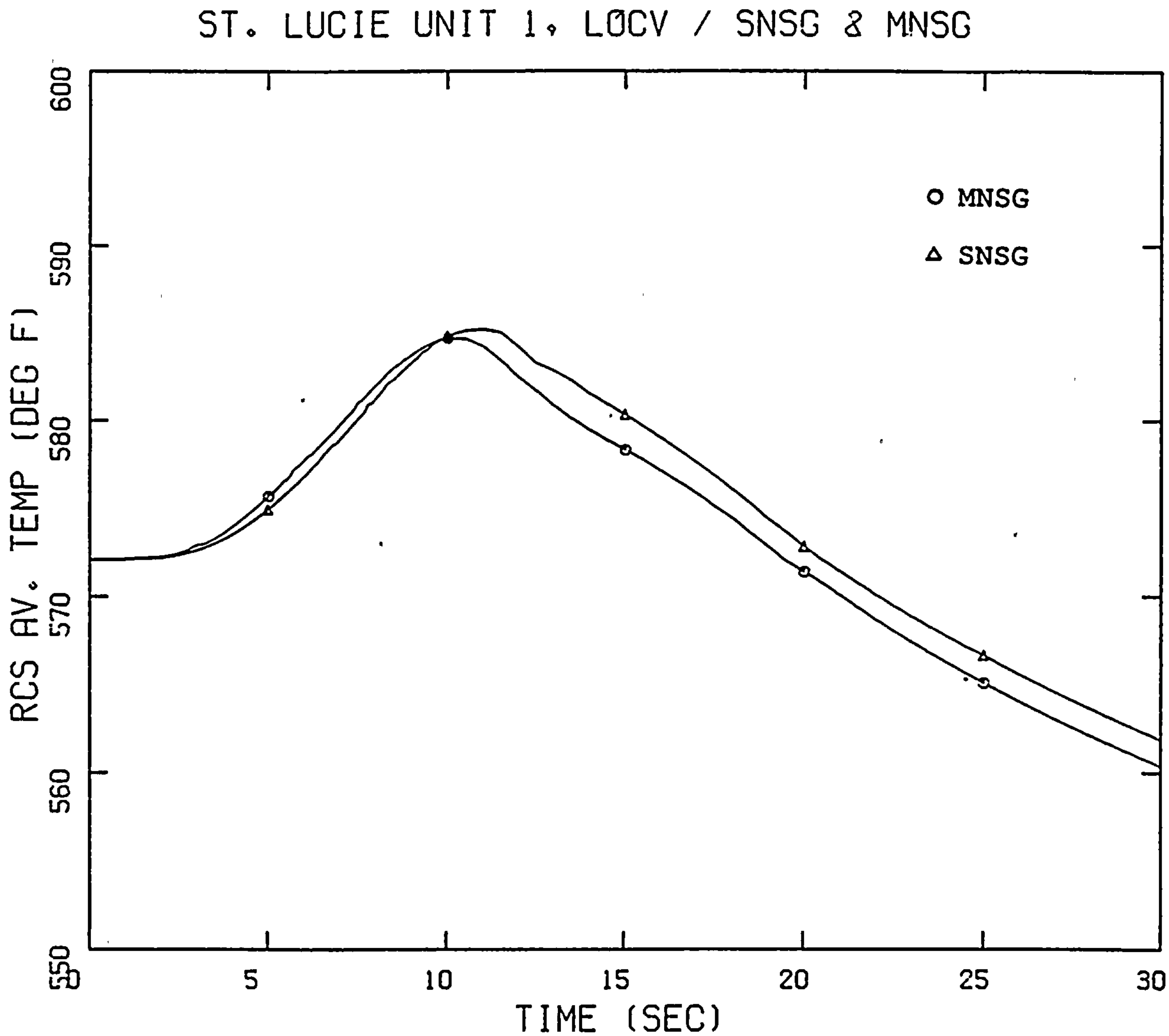

FIGURE 2. ST. LUCIE 1, RCS AVERAGE TEMPERATURE

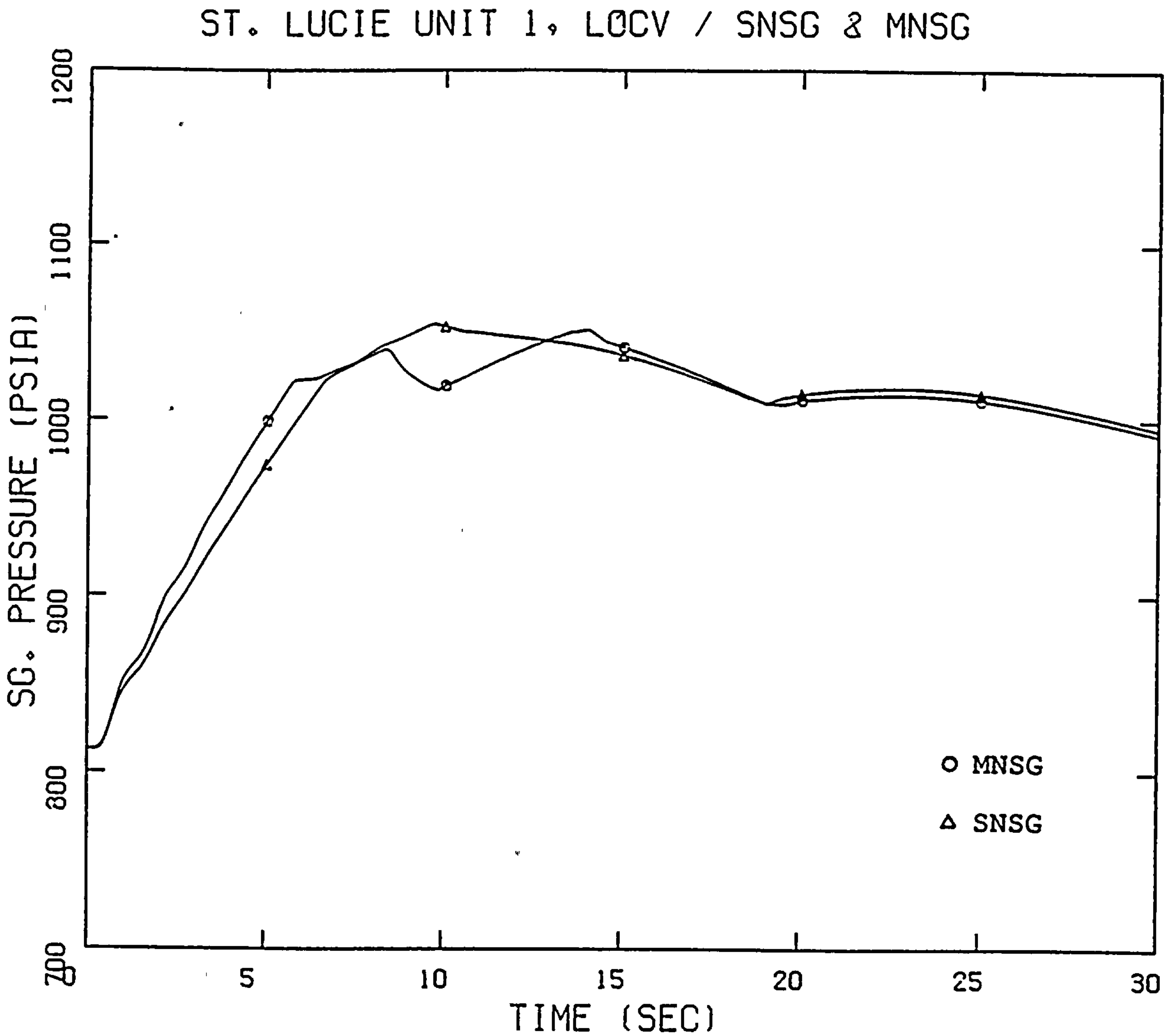

FIGURE 3. ST. LUCIE 1, STEAM GENERATOR PRESSURE

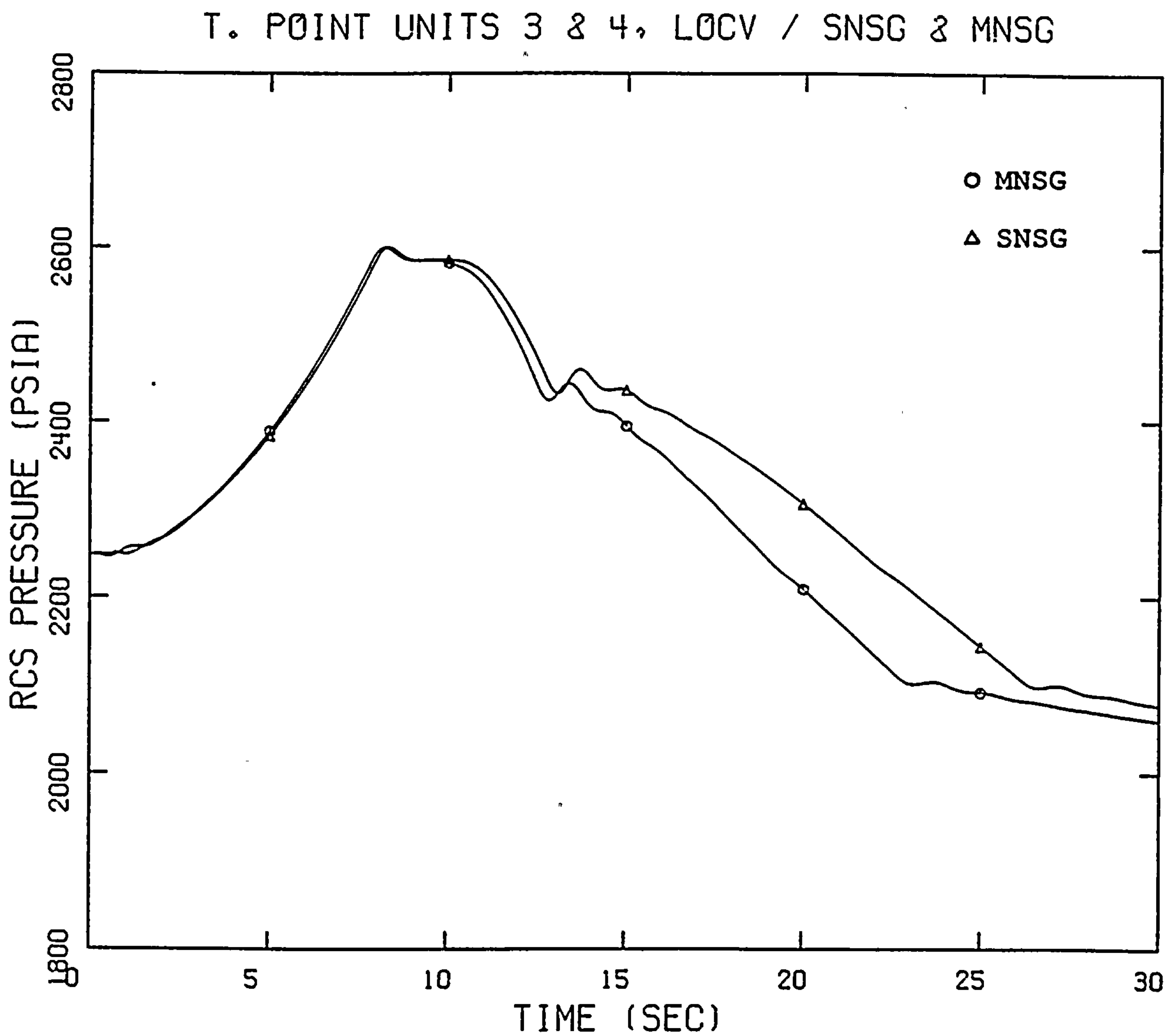

FIGURE 4. TURKEY POINT 3 & 4, RCS PRESSURE

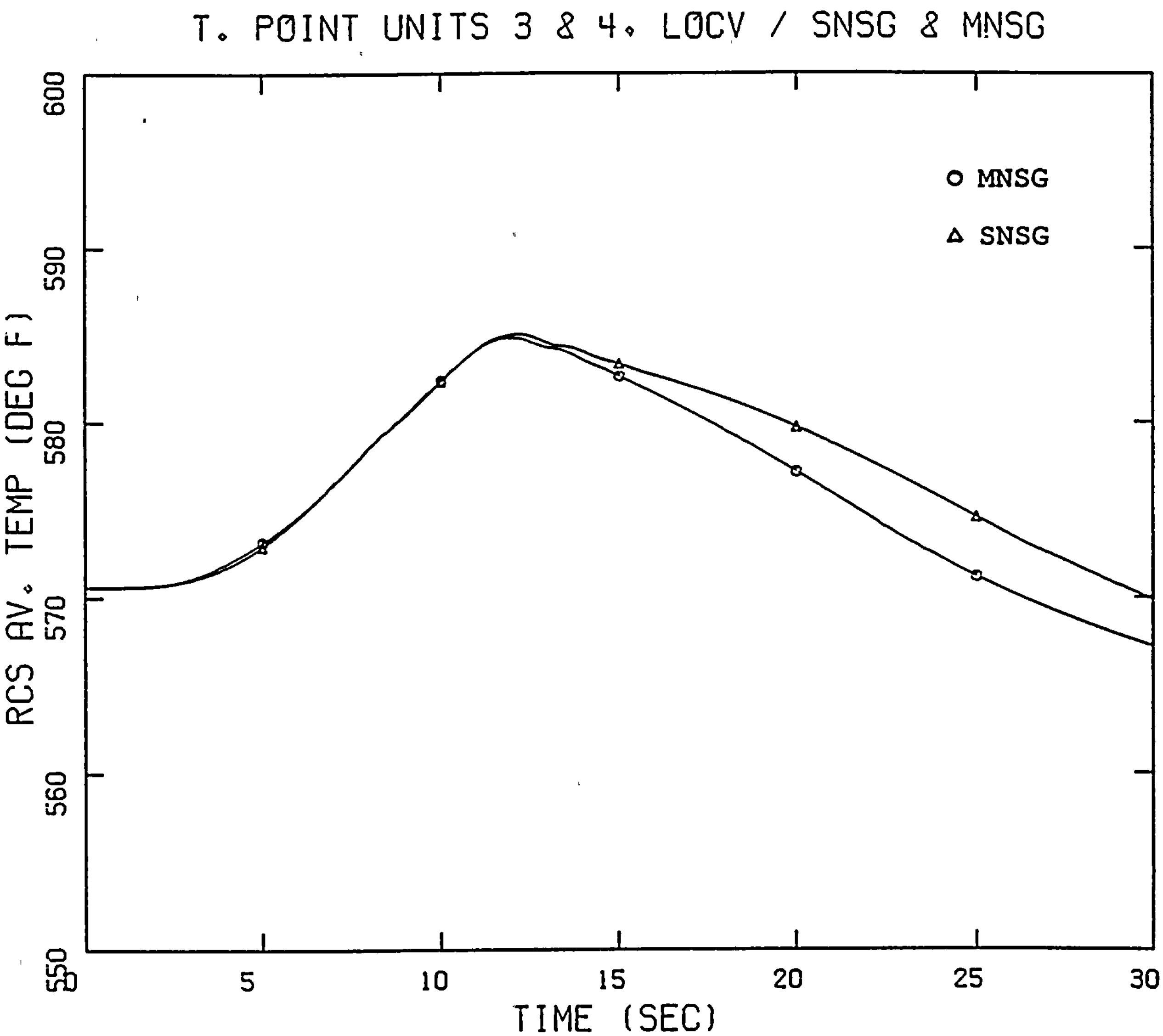

FIGURE 5. TURKEY POINT 3 & 4, RCS AVERAGE TEMPERATURE

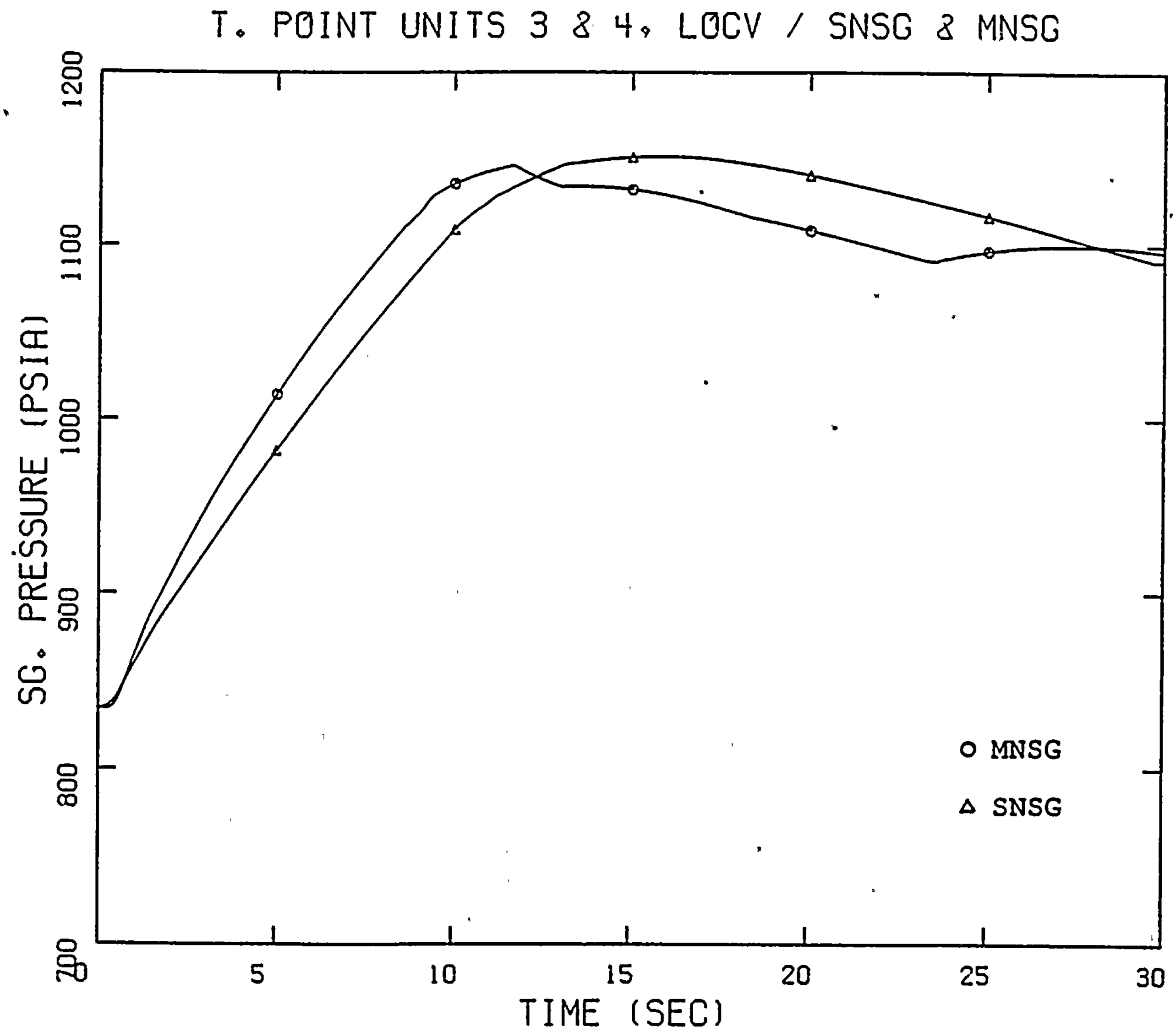

FIGURE 6. TURKEY POINT 3 & 4, STEAM GENERATOR PRESSURE

APPENDIX A

INDUSTRY REFERENCES ON SINGLE NODE STEAM GENERATOR MODELING

The following are references of methodologies previously approved by the NRC which cover the range of plant designs and configurations included in the FPL methodology.

A.1 Questions and Responses Concerning "Transient Analysis Methods for Comanche Peak Steam Electric Station Licensing Applications RXE-91-001", Enclosure to letter TXX-93141 dated March 22, 1993.

This reference compares the responses of SNSG models with and without an explicit preheater model with that of a MNSG model with an explicit preheater model. Besides discussing the need for including the preheater model, the reference concludes that the SNSG results in a more severe transient and therefore it should be retained for licensing applications. The reference provides results of three plant event benchmarks with RETRAN. The three are heatup events. In general, it can be concluded from these results that the primary responses predicted by the MNSG and the SNSG are very similar. For the Turbine Trip event, which is the most severe of the three, primary response is clearly overpredicted by the SNSG. The conclusion reached in the reference is that a MNSG model is not needed for this type of event.

A.2 A-85-11A, "RETRAN Computer Code Reactor System Transient Analysis Model Qualification," Baltimore Gas and Electric Company, January 1986.

This topical report describes best estimate analysis capability, not licensing applications.

Page 13 states: "The single volume secondary side was found to produce acceptable results without the convergence problems and associated longer computer run times of a multinoded recirculating steam generator secondary side RETRAN model".

Page 16 states: "The steam generator secondary side is modelled as a four volume recirculating steam generator with a best estimate recirculation ratio. This model more accurately predicts steam generator performance, but requires considerably greater computer run time and modelling skills for a satisfactory steady state and transient calculations".

Page 213 (in the ATTACHMENT section) states the applicability of the SNSG model: "Therefore, a single node SG secondary is valid whenever accurate level prediction is not necessary or, very large changes in secondary inventory and changes in heat transfer mode on the tube bundle (i.e., counter current flow, primary side condensation) are not expected".

A.3 Garrett, Terry J. and Hseu, Jin-Shou, "RETRAN Benchmark Analysis of Wolf Creek Large Load Reduction Test", Wolf Creek Nuclear Operating Corporation, Proceedings: Sixth International RETRAN Conference, EPRI NP-6949, August 1990, page 9-3.

"A 'simple' steam generator model adequately calculates the mass and energy balance but does not correctly calculate the upper downcomer water level, it can be used for simulating those events not sensitive to the water levels and feedwater flows, such as plant trip. For those events that the water levels and feedwater flows must be correctly estimated, the 'detailed' steam generator model must be used".

A.4 VEP-FRD-41, "Reactor System Transient Analyses Using The RETRAN Computer Code," Virginia Electric and Power Company, March 1981.

The methodology in this reference is based on a SNSG representation. It does not discuss nodalization approaches. It only states that the SNSG type representation is used by other utilities and in vendor analyses.

A.5 NUSCO 140-1, "NUSCO Thermal Hydraulic Model Qualification, Volume 1, (RETRAN)," Northeast Utilities, August 1984.

Haddam Neck - 4 Loop W plant
Millstone 2 - CE plant

Both RETRAN models use SNSG models. Sensitivity studies with the Haddam Neck RETRAN model of a Main Steamline Break (MSLB) transient were performed to support the use of the SNSG model in licensing applications involving MSLB analyses. The conclusions are also applicable to Millstone 2. Page 5 states: "The Millstone 2 model uses the same noding philosophy as the Haddam Neck model. For this reason, it is not considered necessary to repeat the sensitivity studies described in Sections II.B-II.F for the Millstone 2 model since the sensitivity studies would show similar results".