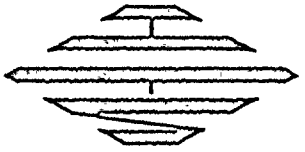
ITS/NRC/87-02
July 1987

Technical Evaluation of FPL Topical Report:

RETRAN Code: Transient Analysis Model Qualification



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1.0 Summary

The Florida Power and Light Company (FPL) submitted a topical report [1] for the purpose of demonstration of their technical competence to utilize the RETRAN computer code for performing transient systems analysis for their Turkey Point and St. Lucie Plants.

The applicant has demonstrated the capability to utilize the RETRAN computer code to perform systems transient calculations on their plants by a series of comparisons between the RETRAN calculated results with FSAR, Westinghouse Generic study results and some plant data. However, no efforts were made by FPL either to qualify or verify RETRAN models for use in transient analysis or to explain in depth the predicted transient behavior, each of which would have provided a basis for evaluation of their understanding of the plant behavior and the RETRAN code. We, therefore, feel that the report does not contain sufficient materials to serve as a document which may be generally referenced to support future FPL licensing submittals.

We recommend, therefore, that in future submittals, FPL should be, on a transient-by-transient basis, asked (1) to thoroughly qualify RETRAN models including nodalizations and control system modeling for their plants and (2) to provide thorough discussion of the transient results.

2.0 Introduction

The FPL topical report entitled "RETRAN Code Transient Analysis Model Qualification" was submitted to demonstrate the technical competence which FPL has developed for performing transient systems analysis with the RETRAN computer code. FPL presented 14 transients in the report: 8 of these are for St. Lucie plants (Combustion Engineering plants) and 6 are for Turkey Point plants (3-loop Westinghouse plants). Six (6) of these transients are compared to the FSAR analyses, five (5) are benchmarked with the actual plant data taken during the events or tests, and three (3) are compared to the Westinghouse Generic Studies. A matrix of these transients is shown in Table 1.

We have reviewed the applicant's efforts to demonstrate their ability to utilize the RETRAN computer code to perform transient analysis for Turkey Point and St. Lucie Plants. Out evaluation is summarized in this report.

3.0 Topical Report Objectives

The applicant's original stated objective of this topical [1] were:

1. to present RETRAN base model verification results for each of FPL's plants. It was requested that these models be approved by the NRC for non-LOCA licensing support analysis. It was intended to demonstrate the adequacy of these RETRAN base models for non-LOCA licensing analysis.

2. to demonstrate the proficiency of FPL personnel to perform system safety analyses per NRC Generic Letter 83-11.

Since the time the original topical report was submitted by the

applicant, the applicant informed the NRC of their desire to reduce the scope of review intended by this submittal as expressed in the applicant's letter L-87-91, dated March 2, 1987 [3]. The revised objectives of the topical report are to:

1. show that the models FPL developed for the Turkey Point and St. Lucie plants adequately simulate the behavior of the plant under steady state and transient conditions,

2. show that the FPL staff knows how to apply the models to a comprehensive and diverse group of transients, so that in future applications of the RETRAN code in licensing submittals, FPL would have already addressed and had reviewed and approved by the NRC Staff the resolution concerns raised in Generic Letter 83-11.

Both of these points have been topics of lengthy discussion among the FPL, NRC, and ITS staff. FPL chose not to provide detailed justification for its nodalization, model selection and control system modeling on a transient-by-transient basis or to provide detailed analysis at this time. Instead, in the future, FPL will either develop a complete licensing methodology topical or will provide sufficient detail to support each licensing action individually. It is, therefore, our understanding that the level of approval now desired by FPL does not include these points in entirety but rather a portion of each, since otherwise FPL would be required to perform more extensive and thorough analysis than was presented in the topical report. Thus the focus of this review is upon the ability of FPL to apply the models they have developed for the Turkey Point and St. Lucie plants to the series of transients to which they have been applied in this submittal.

4.0 Computer Modeling

In general, the term "model' includes three items: (i) the plant

nodalization; (ii) the user selection of phenomenological models from among those programmed in the code (i.e., the bubble rise model or the non-equilibrium model); and (iii) the user generated input which models the plants control systems. Each of these is transient dependent. FPL has not discussed its control system modeling and has only occasionally and briefly discussed its selection of phenomenological models.

4.1 Code Versions

A variety of unidentified RETRAN versions was used by FPL in the analyses presented in the report [2]. RETRAN02/MOD02 has been reviewed and granted limited and conditional approval by the NRC for future use. RETRAN02/MOD03 is a "corrected" version of RETRAN02/MOD02 but has not yet been formally approved by the NRC for use in licensing analysis. Nevertheless, for the purpose of demonstrating technical competence (but not for model qualification), in our opinion it is acceptable to use any of the versions of the code.

4.2 Nodalization

FPL has developed a single-loop plant nodalization for natural circulation cooldown test at St. Lucie Unit 1 using RETRAN01. While this is an acceptable approach in gaining experience in model development and insight into the transient behavior, any future submittals must be performed with an approved version of RETRAN02.

Two-loop nodalizations were also developed and used in the analysis for both plants. Although both of these plant models are briefly described in the report and the nodalization diagrams are presented, this is generally presented without justification since FPL chose not to seek approval for any particular combination of input and RETRAN version for any specific application [3]. In future submittals for qualifying licensing models, sensitivity studies leading to justification of the nodalization

used in the analysis must be presented.

4.3 Modeling

Following up the election mentioned in the preceding section, very little justification of phenomenological or control system modeling selection or discussion of the limitations of these models was provided in the report. Therefore, the applicant must justify its selection of phenomenological models and demonstrate that each is being used within its range of validity on a transient-by-transient basis. In addition, the applicant must also justify its modeling of the plant's control system on a transient-by-transient basis.

5.0 Transient Analysis

The majority of the transients were compared to results submitted in the Final Safety Analysis Reports (FSAR) for St. Lucie and Turkey Point. As such, the presentation of results and discussions were very brief. No discussions of the possible origin of differences between FSAR and FPL analyses were provided to the reviewer, which makes the evaluation of the applicant's understanding of the computer codes and models and its understanding of the specific transient difficult to evaluate. The applicant, in response to our questions, stated in several instances that it could not obtain enough details concerning the code used in the FSAR or the Westinghouse studies, the initial conditions or the assumptions in the FSAR analysis to be able to provide model comparison or to be able to explain the differences in results. Therefore no conclusions can be drawn from these analyses which can be used by the applicant to justify models. Furthermore, because of the lack of detail in the applicant's own analysis, generally, these analyses do not significantly contribute to the applicant's demonstration of its analytical capability. Comparison with Westinghouse Generic Assessment Studies was also lacking details and the plant analyzed was enough different in some cases that only a trend could be compared.

Therefore, those analyses do not serve to qualify plant specific models, although the trend analysis does support, within the conditions mentioned, the applicant's demonstration of ability to utilize the code. Nevertheless, portions of the applicant's analyses of a Small Break LOCA, a Steam Generator Tube Rupture and a Steam Line Break accident contain good discussions of selected phenomenology going on during those transients, and indicate a sound understanding of those portions of those transients. Future submittals containing analyses of entire transients to that degree of discussion together with appropriate cross reference to, and explanation by use of plots of computer output of, various plant parameters would be sufficient to meet the requirements for demonstration of technical competence.

5.1 Turkey Point - Loss of One Main Feedwater Pump Event

The agreement between the code calculations was not very good for the loss of one main feedwater pump event. This particular event was not very helpful in model qualification since the plant monitoring computer failed to record the exact sequence of events and the cause of the reactor trip, and therefore some of the key plant parameters such as core power, hot and cold leg temperature, SG mixture level and feedwater flow rate were not available for comparison. Even the measured feedwater flow rate after the reactor trip was judged to be erroneous. Notwithstanding this difficulty, FPL managed to obtain the global trend.

5.2 Turkey Point - RCP Coastdown Test

The results from the Reactor Coolant Pump Coastdown Test showed that the flows for the case of one pump coastdown appear to begin diverging at about 5 seconds before the test was terminated. FPL indicated that the analysts believe the divergence was unimportant because they presented other analytical results which indicate good results down to less than 20 % flow. Thus, if the applicant had used an approved version of the code, it would

have justified its pump model for the region down to a flow of roughly 40% of nominal where the results begin to diverge.

5.3 Turkey Point - Uncontrolled RCCA Withdrawal

This is a physics dominated transient for which the comparison is between codes, not to experimental data. The computed results appear to diverge toward the end of the calculations. The applicant stated that both the RETRAN and FSAR analyses used the slow withdrawal case with a reactivity insertion rate of 2.5×10^{-5} k/sec, yet the reactor trip times differ by roughly 5 seconds in a relatively short transient. FPL did not analyze the difference, but instead simply stated that the reason for difference was because "these calculations were performed with different codes, by different organizations (leading to differences in input) at different times".

5.4 Turkey Point - Small Break LOCA

Although only code comparison work was submitted in this section, the thorough discussion of phenomena during major portions of this transient demonstrates a good understanding of the code, the phenomena in the transient, and how to do analyses, etc. However, the applicant did not accompany those general phenomenological explanations by cross reference to and explanation by use of plots of the appropriate plant parameters and therefore there are a number of unsupported statements (such as a reference to the existence of countercurrent flow from the top steam generator volumes and the upper head), and it is therefore difficult to evaluate whether these phenomenological discussions are correct. In addition, these discussions do not cover the entire transient, and therefore the analysis is incomplete. Figures presented in the topical show that FPL was able to follow the trends of the transients and since there was no attempt to simulate an identical case by using identical initial conditions and assumptions, this is all one can expect.

5.5 Turkey Point - Stuck Open Steam Generator Relief Valve

The applicant indicated that although most of the initial conditions were obtained from the Westinghouse Generic Study, no attempt was made to exactly match the Westinghouse results. Some assumptions were changed to plant specific rather than generic or were made more conservative to produce a more limiting calculation. Results indicate that the purpose of the analysis was accomplished in that RETRAN began computing lower inlet core coolant temperature at roughly 1300 sec and as much as 30°F by 3500°F. The FPL response provided plausible explanations of certain of the differences between the FPL analysis and that of Westinghouse, (for example, the report suggests that the slower repressurization rate observed in the RETRAN prediction, which roughly starts at 600 sec, is due to a difference in the temperatures of the charging fluid (RETRAN used 40 °F and the flow rate and temperature in the Westinghouse analysis were not known)). Nevertheless, this analysis does not discuss the details of the plant parameter behavior, and is therefore incomplete.

5.6 Turkey Point - Steam Generator Tube Tupture

This analysis was performed as part of PTS considerations and input assumptions were taken from the Westinghouse Generic study and the end point was different than one would use for SGTR analyses. This computation was terminated at 600 sec when the primary and secondary pressures became stabilized (not equilibrated) and therefore the break flow stabilized at about 100 lb/sec. The FPL response included several good discussions of phenomena occurring during the transient which support the conclusion that the applicant has the capability to interpret the results, but as in its presentation of the SBLOCA, the applicant did not either support its phenomenological discussions by cross reference to appropriate plots or cover the entire transient.

5.7 St. Lucie - Natural Circulation Cooldown Event

FPL's topical report stated that "system action and system parameters were modeled to represent actual operating conditions as closely as possible." However, in the response FPL stated that the "FPL RETRAN model for this event was deliberately constructed to provide over-prediction of voiding in the upper head, so as to provide conservative limiting reactor cooldown rates" and not to simulate this event closely. The results do indicate that RETRAN is computing the onset of upper head void formation at roughly 3.75 hours, which is about 0.25 hour earlier than the plant data indicated (see the figure provided with the FPL response). FPL also states that in 1970 they performed an extension study of natural circulation within the upper head which lead to their current nodalization. Presentation of these results should be contained in any future submittal employing and relying on that nodalization.

5.8 St. Lucie - Main Steam Line Break

In comparing the main steam line break transients analysis with RETRAN to the vendor's CESEC computations, the two calculations did not show good agreement in the return to power, which is the primary concern of this transient. The FSAR analysis predicted a return to power of about 1% while RETRAN did not. FPL attributed the difference in return to power to a difference of roughly 0.4% between the total reactivities in the two calculations. In addition, a slightly higher Doppler reactivity was used in the RETRAN calculation. It seems to us, however, that the differences may be due to CESEC's treatment of the vessel and core flows which account for asymmetric effects and which conservatively compute reactivity insertion. Since FPL did not use a split-core, they may not have simulated the CESEC modeling. FPL had a good general discussion of the thermal hydraulic behavior of the primary, but that discussion was not supported by cross reference to appropriate plots, and it is therefore difficult to assess the accuracy of those discussions.

5.9 St. Lucie - Loss of Load

Results of the FPL calculation for a loss of load transient did not agree well with the vendor calculated results. The sequence of events in the topical report covers only the first 14 seconds of the transient when there was a rapid heatup of the primary side, after which there was substantial divergence. In their response, FPL demonstrated that initial pressurizer level had a substantial impact on ensuing pressure response. However, it appears that it would also have been fruitful to investigate the impact of assumed primary to secondary heat transfer coefficients and secondary side modeling since it appears that there are substantial differences between the CESEC and RETRAN predictions of secondary side behavior.

5.10 St. Lucie Generator Trip Test

FPL attribute the difference in the test data and RETRAN results at roughly 10 sec to the one-node steam generator model. FPL states that they recently conducted sensitivity studies with a multi-node SG model, where the SG dome was explicitly modeled, which showed that the sensitivity to the noding can explain a sudden change of SG pressure of this magnitude (20 to 30 psia). The resulting differences in plant parameters may be explained by this change and should, therefore, be included in any future FPL submittal in respect of their analysis of this transient.

5.11 St. Lucie - Main Steam Isolation Valve Closure Event

Results of the FPL calculation for this transient show a reasonable agreement with the test data. The FPL response suggests that the slight discrepancy in the pressurizer level was due to an error introduced in converting the output into the comparable units for plotting purpose.

5.12 St. Lucie Inadvertent Opening of the PORVs

The results show that two calculations agree reasonably well for the first 40 seconds. Around this time, the RETRAN computed secondary side pressure begins to behave very differently from the FSAR pressure which results in the main steam safety valves cycling differently due to the fact RETRAN computes the SG pressure to increase much slower than does CESEC. FPL has attributed the difference to differences in SI flow, break flow and pressurizer models but has submitted no parametric analyses or other supporting analyses. This response is not helpful since it is merely speculative.

5.13 St. Lucie - Loss of Forced Flow

Relatively good agreement was achieved between the RETRAN and FSAR calculated results. There is, however, some inconsistency, since the pressurizer pressure was 15 to 25 psi higher in the RETRAN calculation while the core outlet temperature was roughly 5 °F lower in the RETRAN computation at the peak. The FPL response suggests that this is due to slight differences in the physics parameters, which does not explain the inconsistency.

5.14 St. Lucie - CEA Drop

The FPL response implies that the source of the difference exhibited by the RETRAN and FSAR results with respect to the treatment of reactivity is due to the fact that CE assumed 1.2 seconds to insert the CEAs while FPL assumed 3.0 seconds. This difference between the basic assumptions makes the value of the comparison questionable.

6.0 Conclusions and Recommendations

In conclusion, the section on qualification does demonstrate that FPL is able to utilize RETRAN to perform systems transient calculations on their plant. However, there are a number of outstanding issues which must be discussed and reviewed in greater depth, prior to acceptance of any specific plant analysis by FPL. The comparison of the single- and two-loop models to operating reactor data provides a limited measure of qualification of their plant models and usage of RETRAN but FPL elected not to seek approval for any specific combination of input or code version for any specific application at this point. Therefore, additional comparisons between computed results and test data, together with appropriate nodalization and sensitivity studies should be submitted in future reports using an approved version of RETRAN if these models are to be used in licensing submittals.

The discussion of the code calculated transient results was frequently minimal and was expanded to some degree in the response [3]. In the future, reports which are submitted must contain a detailed discussion of the transients submitted. This would provide the reviewer with the proper material to make a determination as to whether the analyst has the basic understanding of the code calculations and enable complete evaluation of the submitted material for the desired purpose.

Future submittals, in order to be sufficient for approval, should, on a transient-by-transient basis:

(a) describe and justify nodalization;
(b) describe and justify control system modeling;
(c) describe and justify user selection of phenomenological models and demonstrate that such models are being used within their range of applicability; and

(d) present enough plots of physical parameters throughout the plant and discuss the major changes in slope in each by reference to physical phenomena and by cross reference to and with explanations based on the plots of other variables.

7.0 References

1. "RETRAN Code: Transient Analysis Model Qualification," FPL Report NTH-G-6, July 1985

2. FPL's Response to Request for Additional Information, L-87-164, April 10, 1987.

3. FPL Letter L-87-91 from C.O. Woody (FPL) to NRC, March 2, 1987

Table 1.

FPL Transients

Transient Description	Plant	Comments
Natural Circulation Cooldown	St. Lucie	Plant Data 1-loop RETRAN01 model
Main Steam Line Break	St. Lucie	FSAR
Loss of one Main Feedwater Pump Event	Turkey Point	Plant Data
Loss of Load	St. Lucie	FSAR
Generator Trip Test	St. Lucie	Test
MSIV Closure Event	St. Lucie	Plant Data
Inadvertent PORV Opening	St. Lucie	FSAR
Pump Coastdown Test	Turkey Point	Test RETRAN01 plant model

Table 1. Cont'd

Loss of Forced Flow	St. Lucie	FSAR
RCCA Withdrawal	Turkey Point	FSAR
CEA Drop	St. Lucie	FSAR
Small Break LOCA	Turkey Point	Westinghouse GS*
Stuck Open Steam Generator Relief Valve	Turkey Point	Westinghouse GS
Steam Generator Tube Rupture	Turkey Point	Westinghouse GS

* Summary Report on Reactor Vessel Integrity for Westinghouse Operating Plants - WCAP-10019, December 1981.

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July 13, 1987

DOCKET NO(S). 50-250 and 50-251
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- ☐ Environmental Assessment and Finding of No Significant Impact, dated _____.
- ☐ Notice of Consideration of Issuance of Facility Operating License or Amendment to Facility Operating License, dated _____.
- ☒ Bi-Weekly Notice; Applications and Amendments to Operating Licenses Involving No Significant Hazards Considerations, dated 7/1/87 [*see page(s)*] _____.
- ☐ Exemption, dated _____.
- ☐ Construction Permit No. CPPR-_____, Amendment No. _____ dated _____.
- ☐ Facility Operating License No. _____, Amendment No. _____ dated _____.
- ☐ Order Extending Construction Completion Date, dated _____.
- ☐ Monthly Operating Report for _____ transmitted by letter dated _____.
- ☐ Annual/Semi-Annual Report- _____ _____ transmitted by letter dated _____.

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