UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REGARDING GPU TOPICAL REPORT TR-045

"BWR-2 TRANSIENT ANALYSIS MODEL USING THE RETRAN CODE"

GPU NUCLEAR CORPORATION

OYSTER CREEK NUCLEAR GENERATING STATION

DOCKET NO. 50-219

In September 1987, the GPU Nuclear Corporation (GPUN/licensee) submitted a topical report TR-045, "BWR-2 Transient Analysis Model Using the Retran Code," for NRC review and approval. NRC has utilized technical assistance by International Technical Services Corporation (ITS) in the review of the licensee's submittal. The NRC has reviewed the Technical Evaluation Report (TER) and included it as Appendix A of this Safety Evaluation (SE). The staff concurs in the recommendation made by ITS and finds that GPUN's methods in TR-045 are acceptable for reference in licensing analysis under the conditions identified in Section 3.0 of the attached TER. The conditions are: (1) In the use of methods in TR-045, each assumption relating to system parameters and plant protection system responses times should be conservative with respect to the plant data, (2) each code model selection and nodalization used in a plant specific analysis should be consistent with those described in GPUN's TR-045 report and approved in the attached ITS TER.

Based on our review of the licensee's submittal and our contractor's TER, we conclude that the methods in TR-045 are acceptable for GPUN reload analyses when the stated conditions are satisfied.

Dated:

Principal Contributor: Summer Sun

ITS/NRC/88-8
September 1988

APPENDIX A

Technical Evaluation:
GPUN Topical Report TR-045
"BWR-2 Transient Analysis Model Using the RETRAN Code"
Oyster Creek Nuclear Generating Station

1.0 INTRODUCTION

In submission of its topical report, TR-045 entitled "BWR-2 Transient Analysis Model Using the RETRAN Code" (Ref 1.), GPU Nuclear (GPUN) stated its objectives to demonstrate competency to use the RETRAN02 computer code and to qualify a system transient model for the Oyster Creek Nuclear Generating Station with intention for use in licensing reload analysis.

Toward these objectives, GPUN presented in the topical report nine startup test analyses to benchmark control systems and component performance and responses, a sensitivity study on the base licensing model for the limiting Critical Power Ratio (CPR) reload transient (which is a Turbine Trip Without Bypass (TTWOBP) transient) for Oyster Creek, and comparison with three vendor's analyses of Cycle 10 reload transients (TTWOBP, Feedwater Controller Malfunction, and MSIV Closure Without Scram). GPUN further presented results from a statistical analysis to determine the operating limit minimum CPR (MCPR) utilizing the General Electric Company Thermal Analysis Basis, GETAB, to combine all of the uncertainties in operating parameters and the procedures used to calculate critical power ratio.

This review evaluates the licensee's analyses performed with the RETRAN02 MOD004 computer code for use in licensing analysis. The information reviewed consisted of the subject topical report and supplements (Refs 2., 3., and 4.) thereto provided by the licensee.

2.0 EVALUATION

2.1 Base Model

2.1.1 Plant Nodalization

GPUN developed a base model for the Oyster Creek plant containing, among other volumes, a 12-hydraulic node core with 24 neutronic nodes, two eight-volume steam lines, a steam separator and a non-equilibrium volume representing the upper downcomer. The algebraic slip option was selected in the core. The RETRAN two-region separator option was selected for a separator component representing the 151 individual steam separators. The base model also contains two recirculation loops representing one and four loops respectively. The transport delay option was used in the recirculation loop piping, the lower downcomer and lower plenum. The transport delay option was also selected for the feedwater line volume. The Moody critical flow option was used for all choked junctions.

Kinetics input data were generated to reflect the end of cycle conditions. The limiting transient was analyzed using the one-dimensional (1-D) kinetics option in the RETRAN02 MOD004 version. Other transients were performed using the point kinetics option. The 1-D kinetics option in the RETRAN02 MOD004 was previously reviewed and found to be acceptable for use in this context.

GPUN's use of the separator model was consistent with the vendor's data for carryunder and carryover and was within the restrictions placed upon use of this model in the RETRAN02 SER relating to (a) fluid transient time through the separator and (b) on not using the model in a reverse flow mode. We therefore find GPUN's use of the separator model acceptable.

GPUN's nodalization of the downcomer as a single node upper downcomer and a single node lower downcomer is consistent with the need for non-equilibrium modeling in the two phase region in the upper downcomer (which GPUN did) and equilibrium modeling in the lower downcomer (as they did). Because of the so called "pancake" problem that would occur in RETRAN calculations for stacked two-phase nodes, GPUN chose not to subdivide either region further. This approach is consistent with the approach used by the industry, and we find this nodalization acceptable.

GPUN's use of the non-equilibrium model in the upper downcomer region is acceptable since the use of non-equilibrium modeling is necessary in that region to represent the steam flowing in from the separator and the cooler liquid present in the lower portion of that volume. However, as restricted in the RETRAN02 SER (Ref 6.), the licensee should provide additional justification for conditions with single-phase fluid in the upper downcomer if such conditions occur.

GPUN's nodalization of the reactor vessel is equal or more detailed than that used for comparable BWR cores by other licensees. On that basis we find the core nodalization acceptable.

GPUN's nodalization of the balance of the reactor system (recirculation loops, etc.) is such that each significant component or connecting pipe is represented by a separate volume. We find this approach acceptable.

GPUN provided justification of its RETRAN nodalization based to some degree upon a study performed to determine impact on the difference between the ratio of the maximum delta CPR and the initial CPR for the perturbed and unperturbed conditions (which is used by GPUN as the measure of the impact of the perturbation and is called the delta RCPR). The results indicated that, except for the steam line nodalization, nodalizations used in the base model for the core, reactor vessel and recirculation loop volumes were determined to be more conservative than those obtained by using other noding schemes (i e., finer noding). GPUN justified its steam line nodalization by reference to studies performed by EPRI and by Yankee Atomic and by noting that the GPUN nodalization would result in shorter nodes than the EPRI study (which generally yields more accurate results). In addition, sensitivity studies performed by GPUN indicate that the base nodalization gave more conservative results than the EPRI nodalization. We find this acceptable for the base model.

We find that GPUN adequately demonstrated its knowledge of such models, their limitations and range of applicability, therefore, we conclude that GPUN's nodalization and use of special purpose non-equilibrium and separator models in its base model is acceptable.

Since use of the algebraic slip option with the RETRAN02 has not been approved (Refs 5. and 6.), the licensee elected to demonstrate that transient analysis using this option would result in more conservative results than those obtained by the vendor for each transient analyzed. We find this approach acceptable. The licensee's results indicate that the RETRAN02/RACE combination, as so used, gives more conservative results than those of the vendor. On that basis, we find the licensee's analysis acceptable. However, future analyses should retain the conservatisms in the use of RETRAN02 contained in this submittal since it was the RETRAN02 conservatisms which caused the overall RETRAN02/RACE results to be more conservative than the vendor's computations. The licensee should provide justification for any deviations in the future plant specific submittal.

2.1.2 Critical Power Ratio Computation

The critical power ratio was computed for each transient using the GPUN-developed RACE computer code in which the CPR is computed from the GEXL correlation using certain system parameter input from the RETRAN hot channel model using a 24 node core.

The GPUN RETRAN hot channel model calculates hot bundle transient flow, subcooling, power and core average pressure. Transient power is calculated using RETRAN02 system model. RACE computes quality in every node along the bundle using the bundle transient power, pressure, and flow taken from the RETRAN hot channel model calculation. After the nodal quality and boiling length are calculated, the GEXL correlation is used to determine whether critical quality has been reached anywhere along the bundle. If not, the code increases bundle power and the process is repeated until critical quality as calculated by GEXL is reached. The ratio of that power to initial power at that time step is the CPR for that time step. This procedure is repeated for every time step.

This methodology was used to benchmark publicly available critical heat flux data and some data that was available from the GE CHF data base (Ref 2.). GPUN has stated that its study resulted in the mean CPR computed by RACE for a 7x7 data base being 1.0054 ± 0.0248 which falls in the one sigma band of the published result of 0.9885 ± 0.0360 for that data base. This result indicates that the RACE predictions for CPR are accurate in a statistical sense.

The accuracy of the RACE methodology was further examined by comparison with the vendor's hot channel code. In order to eliminate differences due to the systems code models, GPUN took necessary input to RACE from the ODYN run. Comparison between ODYN/SCAT and ODYN/RACE results indicated that in most cases, the RACE results were more conservative than those using the SCAT code (a GE hot channel code). For the cases where the RACE results indicated less conservatism, the differences were attributed by GPUN to the use of a normalized hot channel flow based on the core average flow instead of using actual hot channel flow which would be lower later in the transient calculation. This analysis indicated that GPUN understood the accuracy of their RACE methodology and the source of differences from the vendor's results.

Although the forgoing ODYN/RACE results were not all more conservative than the vendor's results, the GPUN RETRAN/RACE results uniformly gave higher MCPRs for all the transients computed and presented, and therefore, for such transients RETRAN/RACE results are found to be sufficiently conservative. On this basis, RACE was found acceptable, not as a stand-alone code, but rather as a code to be used with RETRAN02 for the Oyster Creek Generating Station.

2.1.3 Control Systems

Two control systems were developed: the feedwater controller and the electric pressure regulator. The feedwater controller calculates the feedwater flow as a function of a difference in setpoint and sensed liquid level adjusted to reflect area changes in the separator/standpipes/steam dome regions and provides for steam-feed mismatch to the level error. The electric pressure regulator controller models the pressure regulating components such as the four turbine control valves, nine bypass valves, and turbine hydraulic model.

Two startup test simulations, pressure regulator and level setpoint change tests, were performed to qualify these control systems. We find the results of the comparison indicate reasonable models of the actual control systems.

2.1.4 Geberal Model Qualification by GPUN

In addition to the two startup tests used to benchmark the control systems, seven other tests summarized below were chosen to benchmark the noding scheme, code options and the adequacy of calculational procedures:

Objective	Tests Used
1. Steam line model benchmark:	Turbine trip without bypass and generator trip with bypass.
2. Liquid level model benchmark:	The level setpoint change and the MSIV closure test.
3. Bypass valve sizing:	Bypass valve test.
4. Isolation condensers benchmark:	Isolation condenser test.
5. Recirculation pumps benchmark:	Recirculation pumps trip test and the power flow control test.

When comparing computational data with the average value of various plant parameters, GPUN developed an acceptance criterion of 15% error margin. This was derived by assuming that there was a 10% error margin in the plant data which was to account for uncertainties in instrumentation reading and translating those data into RETRAN02 input data, and an additional 5% error margin as an approximation of the margin of one standard deviation (or one sigma) of the measurement uncertainties of the plant data.

In most cases the GPUN acceptance criterion was met. Where it was out of the range, the RETRAN computed parameters indicated more conservative behavior, and therefore were found by GPUN to be acceptable. We find this approach to be reasonably based upon instrument accuracy and engineering judgement, and therefore to be acceptable.

2.2 Analyses

The base model was compared to vendor analysis for three Cycle 10 reload transients (the Cycle 10 core contains both GE 8x8 and EXXON VB fuels); the turbine trip without bypass (TTWOBP), the main steamline isolation valve closure without scram, and the feedwater control failure to maximum demand. The vendor analyses were performed with the ODYN code.

Because details of the ODYN analyses were not available to the licensee, and there exist model differences between RETRAN and ODYN, a simplistic comparison is not necessary meaningful. The ultimate acceptance criterion is that the critical power ratio (CPR) is more conservatively computed by the set of codes used by GPUN than by GE.

In order to determine a conservative CPR, a sensitivity study was performed for the TTWOBP transient, which represents the most limiting CPR for the pressure increase category. First, the CPR variabilities due to various plant parameters, code models, physical dimensions, nuclear parameters were determined. These responses were later statistically combined to yield an overall CPR multiplier which would be used in the base model calculation result to assure a 95/95 MCPR limit.

The original sensitivity study presented in the topical report was performed using the dynamic slip model. It was later found that the algebraic slip model yielded comparable or more conservative results than the plant data. Thus the licensing model uses the algebraic slip model. Therefore, an additional model uncertainty associated with use of the algebraic model was added (Ref. 2) to the parameters used in the sensitivity study listed in Table 4.4 of Reference 1. With these additional parameters, the overall multiplier to the MCPR expression was raised to 1.049 from 1.042 reported in TR-045. Thus, 1.049 will be used in the future reload analysis.

2.2.1 Turbine Trip Without Bypass

GPUN provided a detailed and thorough analysis of this transient, since all model options are exercised during this computation. This is also the transient used for the sensitivity study as described above. In this transient, the turbine is assumed tripped by closure of the turbine stop valves and the steam bypass valves failed to operate to relieve pressure. The scram signal is assumed received from the 10% stop valves closure signal.

The RETRAN02 computed plant parameters exhibited the same trend as those computed by the vendor using ODYN, and in most of the cases, RETRAN02 obtained more conservative results. The delta CPRs for both GE and EXXON fuels were computed by RETRAN02/RACE to be more conservative than those obtained with the vendor's codes.

The GPUN analysis and results adequately demonstrate GPUN's knowledge of the RETRAN02 computer code and GPU's ability to understand and explain the results. On this basis, we find GPUN to have demonstrated its ability to perform analysis of the Oyster Creek plant using RETRAN02.

2.2.2 Main Steamline Isolation Valve Closure Without Scram

The transient is initiated by the simultaneous closure of all main steam isolation valves with the failure of the reactor protection system. This transient was analyzed to determine the adequacy of the safety valves to prevent vessel over-pressurization. The discharge coefficient for the safety valves was set to deliver rated flow at rated pressure. CPR was not calculated for this transient.

The results showed that comparable trends were obtained for the key plant parameters presented in the topical report. Where there exist differences in timing of events and the amplitudes of computed plant parameters, GPUN stated that they were due to differences in closure characteristics of the MSIV and in kinetic parameters between RETRAN02 and vendor's code. Thus GPUN demonstrated the ability to model an MSIV closure event and some understanding of the impact of MSIV characteristics on the transient results.

2.2.3 Feedwater Controller Failure

The transient assumed the failure of the feedwater control system in the maximum demand position with initial level at the low level alarm setpoint. The maximum feedwater flow used was 120% of rated flow using the same ramp time as used by the vendor.

Plant parameters were computed to be comparable to those obtained by the vendor. The RETRAN/RACE computed delta CPRs are within 1% of GE results for both GE and Exxon fuels, and were more conservative. Therefore we find this analysis to be acceptable.

3.0 CONCLUSIONS

GPUN's topical report "BWR-2 Transient Analysis Model Using the RETRAN Code," TR-045, and supplemental information provided by GPUN in support of its submittal were reviewed. We find that the licensee has demonstrated its technical competence to use RETRAN02 MOD004 and analyze results obtained by the use of this code for applications of the Oyster Creek plant transients. We further find the topical report, TR-045, when considered together with the supplements thereto contain sufficient information to be referenced in the future reload analysis. We recommend, however, that any reload analyses be reviewed to ensure conservatism and consistency with this submittal; i.e., (i) each assumption relating to system parameters and to plant protection system response times should be conservative with respect to the plant data, and (ii) each code model selection and nodalization used in plant specific analysis should be consistent with those approved in this TER.

4.0 REFERENCES

1. "BWR-2 Transient Analysis Model Using the RETRAN Code," TR-045, Rev. 0, GPU Nuclear, September 3, 1987.

2. Letter from R.F. Wilson (GPU) to USNRC, "Oyster Creek Nuclear Generating Station (OCNGS) Reload Topical Report 45," dated September 2, 1988.

3. "Oyster Creek Nuclear Generating Station GPU Nuclear Topical Report 045 Response to Reqeust for Additional Information," attachment to letter from R.F. Wilson (GPUN) to USNRC, dated June 14 1989.

4. "Oyster Creek RETRAN Model Startup Tests Benchmark," TDR 824, GPU Nuclear, January 21, 1987.

5. "Technical Evaluation Report on RETRAN02 MOD003 and MOD004," ITS/88-7, July 28, 1988.

6. Letter from C.O. Thomas (USNRC) to T.W. Schnatz (UGRA), "Acceptance for Referencing of Licensing Topical Report EPRI CCM-5, 'RETRAN-A Program for One Dimensional Transient Thermal-Hydraulic Analysis of Complex Fluid Flow System,' and EPRI NP-1850-CCM, 'RETRAN-02-A-Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems,'" September 4, 1984.